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Fire Ecology Monitoring Protocol for the Heartland Inventory and Monitoring Network

Natural Resource Report NPS/HTLN/NRR—2011/294

ON THE COVER
Herbert Hoover birthplace cottage at Herbert Hoover NHS, prescribed fire at Tallgrass Prairie National Preserve, aquatic invertebrate monitoring at George Washington Carver National Monument, the Mississippi River at Effigy Mounds National Monument.

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Abstract

Fire has played an important role in shaping the plant and animal communities of the Central Great Plains region. Lightning fires as well as those of anthropogenic origin were frequent during the period of historical interest for most parks. An era of fire suppression has led to changes in natural communities, however. Current prescribed fire programs in the region aim to restore or maintain ecosystems and reduce fuel loads in hopes of preventing catastrophic wildfire.

The fire ecology program for the Central Great Plains region, embedded within the Heartland Inventory and Monitoring Network (HTLN), is multifaceted. It serves as an integrating factor among the vital signs projects already in place within HTLN as well as integrating HTLN into the Midwest Region Fire programs. Field data collection that began in 2009 complements and enhances long-term data analysis previously established within HTLN. The current NPS-Fire strategic plan highlights the value of collaboration between Fire Ecology programs and Inventory and Monitoring networks.

Sampling methods used are a hybrid of those described in the HTLN vegetation monitoring protocol and the NPS Fire Monitoring Handbook. The fire ecology program has adapted the protocols described in the Fire Monitoring Handbook to synchronize with the existing sample site array established by HTLN. In this way, both short-term fire ecology data and long-term vegetation monitoring data are collected in a complementary fashion. The short-term fire ecology data enhances understanding of potential disturbance related trends.

Acknowledgments

Mike DeBacker envisioned the need for this program and has fostered its development. Development of the HTLN Fire Ecology program has been a truly cooperative venture from funding to implementation. We are grateful to the National Park Service Fuels program for providing funding. We appreciate the willingness of HTLN park staff to work with us to develop new methods of data collection and reporting. This protocol was based on a template written by Cody Wienk for the Northern Great Plains Fire Ecology Monitoring Network. We would also like to thank three peer reviewers for their insightful comments and suggestions.

Introduction:

The Heartland I&M Network (HTLN) Fire Ecology program grew from recognition of the need for fire ecology support for several parks in the Midwest region without a dedicated fire ecologist. These parks include Effigy Mounds NM, George Washington Carver NM, Herbert Hoover NHS, Homestead NM of America, Pipestone NM, Tallgrass Prairie National Preserve, and Wilson's Creek NB. Fire ecologists at Ozark Highlands and Voyagers work with the remaining HTLN parks that use fire as a management tool (Figure 1).

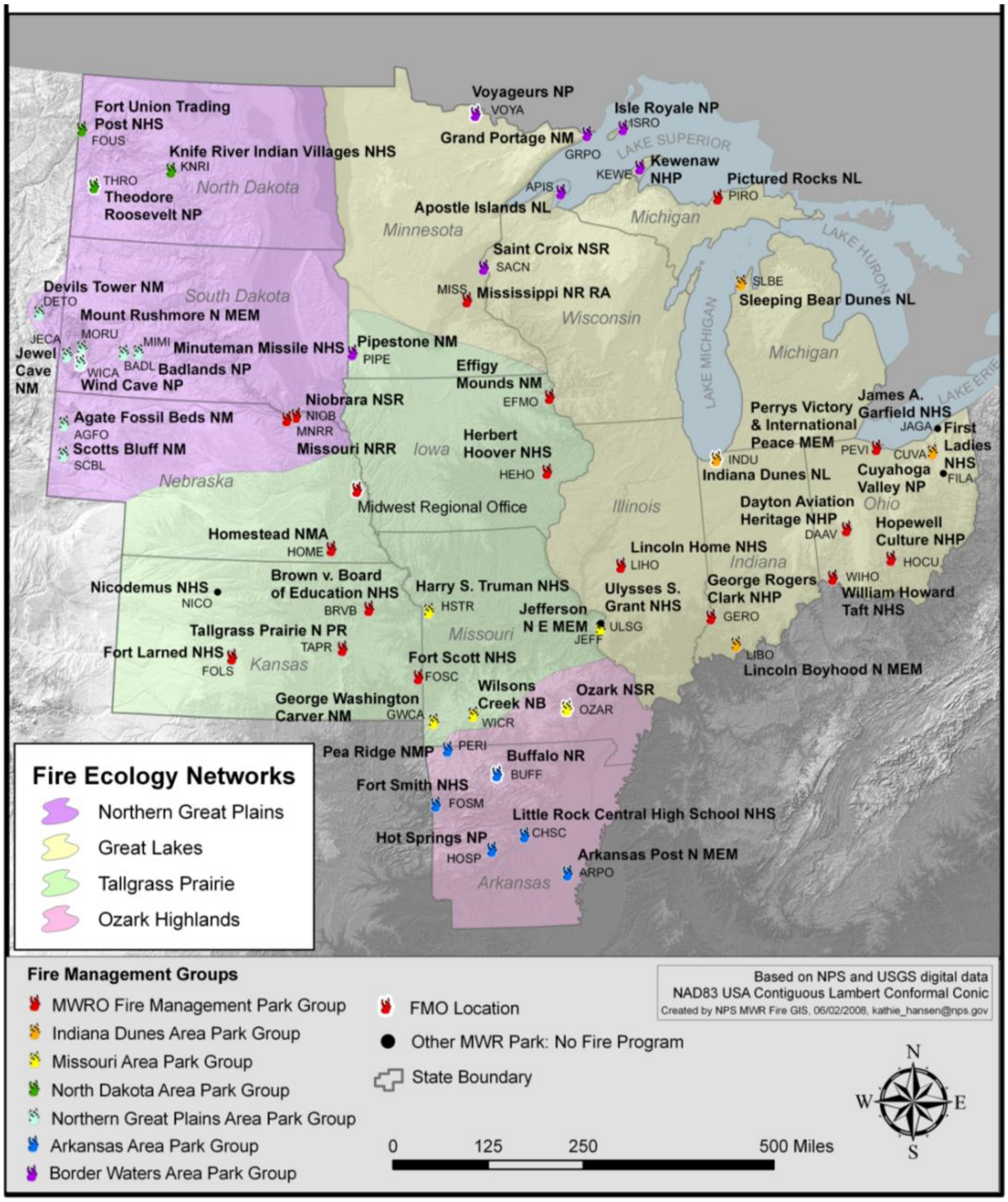

Figure 1. Fire ecology networks in the Midwest region. Heartland Network parks are shown in green.

While HTLN has been monitoring long-term changes in the plant communities for some time, the network lacked fire-specific data to help explain trends. The fire ecology project builds on the long-term trend data by collecting fire related variables. Data collection methods draw on both the HTLN long-term monitoring and NPS fire ecology programs. By using this hybrid approach, we hope to enhance both programs resulting in the best possible information being delivered to the parks.

Fire has played an important role in shaping the plant and animal communities of the Central Great Plains region (Axelrod 1985, Anderson 2006). Fires caused by both lightning and people were frequent during the period of historical interest for most parks (Frost 1998, Stewart 2002). Fire was eventually suppressed, thereby changing natural communities (Ladd 1991, Sieg 1997, Stambaugh et al. 2006, Stambaugh et al. 2007). Current prescribed fire programs in the region aim to restore or maintain ecosystems and reduce fuel loads to prevent catastrophic wildfire.

Fire also played an important role in shaping the cultural and historic landscapes of National Parks within the HTLN. Scientists estimate the loss of native prairie ranges from 80 to 99.9%, with the greatest losses occurring in the tallgrass prairie and oak savanna communities. Furthermore, only 71% of shortgrass prairie and 59% of mixed-grass prairie remain (Knopf and Samson 1997). The synergy between fire and ungulate grazing is widely recognized as a critical component of the natural disturbance regime in tallgrass prairie ecosystems (Bragg 1995, Davison and Kindscher 1999, Howe 1999, Collins 2000). Lightning fires that ignited sun-cured prairies, glades, and drought stricken woodlands were a part of the natural environment (Frost 1998). Human activity supplemented and intensified naturally occurring fire. American Indians used fire as a tool for wildlife and vegetation management, insect control, and warfare. Fires also started as a result of new settlements formed by European immigrants (Pyne 1984, Bragg 1995, Guyette 2002). Fire and grazing interact with climate and weather to affect spatial and temporal dynamics (Collins 1987, Knapp and Seastedt 1998, Knapp *et al.* 1999, Collins 2000). Due to the complex disturbance regimes, grassland systems consist of dynamic mosaics of vegetation patches scattered across the landscape, highly variable in both space and time (Collins and Glenn 1991, Collins and Glenn 1997, Collins 2000, Fuhlendorf and Engle 2001).

Similar to grassland ecosystems, oak-hickory forests developed under a complex disturbance regime. Oak savannas form transition zones within the eastern prairie while oak-hickory forests once formed large tracts across the landscape from southern Arkansas to northern Iowa and east to Ohio (McShea and Healy 2002). Oak-hickory communities can be thought of as being in a constant state of recovery from varying degrees of natural disturbances (Johnson et al 2002). However, with the elimination or control of fire, much of the natural disturbance regime has been changed, which is currently reflected in the composition and structure of these forests (Nelson 2005).

Today, National Park Service ecologists and natural resource managers use fire to maintain, restore and reconstruct prairies, glades, savannas, and woodlands for both cultural and natural resource benefit and to reduce hazard fuel loads. The use of fire can support woodland management goals by affecting both overstory and understory species composition and density (Brown and Kapler 2000, Brose et al. 2006). Prescribed fire can also help to rehabilitate natural communities, such as prairies and savannas, by reducing woody shrubs and increasing native species diversity (Knapp et. al. 1999, Bragg 1995, Collins et. al. 1995). Occasional fire provides important benefits to multiple ecosystems including: stimulating native plant production, controlling invasive plants (especially woody plants in grasslands) releasing nutrients back into the soil to enhance plant growth, suppressing non-native species, and inhibiting disease and insect infestations (Brown and Kapler 2000).

Program goals and objectives

Although each park may define a specific set of goals and objectives for a prescribed fire treatment or series of treatments or even maintenance cycles, the fire ecology monitoring program has established its own set of goals and objectives. The HTLN fire ecology program goals are two-fold: 1) integrate fire ecology data with long-term monitoring data to provide the best understanding of grassland and woodland resources possible, and 2) function in a liaison role by bringing together normally disparate groups of NPS staff, such as park staff, regional fire ecology and operations staff, and I&M staff to share data and work towards common goals. Two important desired outcomes of these goals are:

1. To provide park natural resource managers and fire management staff with feedback relative to their prescribed fire goals and objectives through data collection, reporting, and development of outreach products.

2. To supplement HTLN long-term monitoring data with short-term fire ecology data so that cause and effect relationships can be more easily discerned and long-term trends better understood.

Specific measurable objectives of the fire ecology program will guide programmatic evaluation over the long-term. Objectives of this program are:

1. Assess trends in fuel loads as they relate to prescribed fire. Compare fuel loads and changes to goals stated in parks' Fire Management Plans (FMP) and/or Fire Monitoring Plans.

2. Maintain a spatial record, including pertinent metadata, of prescribed fires in the parks. This record will be maintained by HTLN but shared with parks and the regional Fire GIS Specialist.

3. Use environmental variables, such as fire behavior and fuel moisture, to understand fire effects as they relate to goals and objectives stated within FMPs and/or Fire Monitoring plans.

Task Areas

The NPS Fire Monitoring Handbook (2003) identifies four levels of fire monitoring:

- Level 1 – Environmental
- Level 2 – Fire observation and reconnaissance
- Level 3 – Short-term change
- Level 4 – Long-term change

This protocol outlines field procedures for collecting fire ecology data prior to a burn, during a burn, and immediately post-burn (Levels 1 and 2). Although, traditionally, fire effects monitoring teams have collected plant community data in addition to fire specific data, we will rely on the long-term plant community data that the HTLN program collects. HTLN long-term vegetation monitoring protocols (Levels 3 and 4) are published and available on the web http://science.nature.nps.gov/im/units/htln/ (James et al. 2009). Plant community data are stored in an Access database.

To accomplish the goals and objectives stated above, the program will concentrate on several areas:

1. Participate in prescribed fires so that level 1 data (weather, fire behavior, and burn progression) is formally recorded and detailed reports are written and shared among interested parties.

2. Collect pre- and post-burn Level 2 data.

3. Conduct analyses to determine effects of fire on terrestrial communities and report results.

4. Apply the data generated from tasks 1-3 to support park planning efforts.

5. Transfer fire ecology information from the broader scientific community to practitioners as well as sharing monitoring results with network partners by way of briefs, summary reports, and review papers for internal and/or public consumption.

6. Encourage/facilitate fire ecology research projects within parks where appropriate.

Program Administration

The HTLN Fire Ecology program operates under the administrative umbrella of the Heartland Network. Administrative and technical oversight is provided by the Network's Board of Directors (BOD) and Technical Committee (TC), respectively. The roles, responsibilities, and composition of the BOD and TC are described in the network charter. Fire Ecology operations are fully integrated within the network and are supported by network administrative, GIS, data management, and quantitative ecology staff. Annual administrative reporting and work plans are incorporated into the Network's Annual Administrative Report and Work Plan. This administrative arrangement, whereby fire effects and vital signs monitoring are closely integrated, is consistent with Reference Manuel 18 (p. 17; National Park Service 2008).

Permanent funding is being sought for the HTLN Fire Ecology program. In the interim, fire ecology support is provided through a cooperative agreement with Missouri State University with financial assistance from the NPS Fuels Program. The cooperative agreement is administered through the Great Rivers Cooperative Ecosystems Studies Unit and is overseen by the HTLN Network Coordinator. The cooperative agreement was initiated in 2007 and is funded through 2012.

Sampling Design

Sample Size

Required sample size for Level 1 and 2 monitoring is a minimum of three sites (macroplots). When only minimum sample sizes are possible, three samples more accurately represents the population standard deviation than two; using only two samples would likely over estimate standard deviation. Larger burn units should have a proportionally larger sample size to be able to accurately capture variability. Sample size is also based on the amount of time available for monitoring (effort). In most cases, pre-burn sampling must be completed within a half to one day (excluding travel time) and calculations of sample size are constrained by that time frame. For a crew of three, 10-12 grassland and 4-6 woodland sites may be completed within one day. A crew of four can work in pairs to complete additional plots. Once adequate amounts of data are collected to calculate variability and power by burn unit, sample sizes and staffing should be reevaluated. In parks with small burn units, sample sites may be installed or designated based on the whole burn perimeter rather than individual burn units (Table 1).

Spatial Design

Level 1 & 2 fire effects monitoring sites are co-located with vegetation vital signs monitoring sites whenever possible. An array of permanently marked plots comprises vegetation vital signs monitoring for a park. The spatial design of vegetation vital signs monitoring generally allows inference to management units and the park as a whole (James et al. 2009). For Level 1 & 2 monitoring, the relevant spatial unit is often the burn unit, or cumulative area burned (particularly in smaller parks). In some cases, too few vegetation vital signs plots will occur in the area of interest, in which case, additional Level 1 & 2 monitoring sites are deployed. These supplemental sites (aka virtual sites) are co-located with breeding bird vital signs monitoring sites (Peitz et al. 2008). Virtual sites are chosen at random from a pool of breeding bird points within the area of interest (SOP 3). These sites are not permanently monumented, but rather are navigated to using GPS. Once a virtual site has been established, it will be revisited when that burn unit is treated in the future. Table 1 summarizes the spatial design by park unit. A map of sampling locations can be found in Appendix 1.

Table 1. Type of sites deployed by park unit as of spring 2010.

Park	EFMO	GWCA	HEHO	HOME	PIPE	TAPR	WICR
Number of burn units	16	11	8	5	5	8	24*
Number of vegetation monitoring sites park-wide	29	7	6	10	12	30	12
Fire effects monitoring sites based on burn units (U) or area to be burned (A)	U	A	A	A	U	U	U
Vegetation monitoring sites adequate	N	Y	N	N	N	N	N
Virtual fire sites needed	Y	N	Y	Y	Y	Y	Y
**Approximate travel time to park (hrs)	9	1	7	6	9	6	<1
Comments	Virtual sites will supplement vegetation monitoring sites		Two virtual sites currently installed.	Two virtual sites currently installed.	Four virtual sites installed in Unit 4.	Ten virtual sites currently installed.	Three virtual sites currently installed.

*Burn unit designations have not been finalized.

**From Missouri State University campus.

Methods

Sampling methods used are a hybrid of those described in the HTLN vegetation monitoring protocol and Fire Monitoring Handbook. The fire ecology program has adapted the protocols described in the Fire Monitoring Handbook to synchronize with the existing sample site array established by HTLN. In this way, both short-term fire ecology data and vegetation monitoring data are collected in a complementary fashion. The short-term fire ecology data enhances understanding of potential disturbance related trends.

Level 1: Environmental

This level provides a basic overview of the baseline data that can be collected prior to a burn event. The cadre of data consists of weather, daily fire danger rating, and staffing levels (during the fire season), fuel moisture, soil moisture, fuel load, and geographic information.

Weather

Broad links to weather and fire weather data within the HTLN include:

- *RAWS* – http://www.raws.dri.edu/
- *ROMAN* – **http://raws.wrh.noaa.gov/roman/**
  ROMAN houses all data from the GOES weather stations. Data from the most recent observation at the station is available on the home page of each station. Past data can be found by following the 'Past Data' link.
- *Western Regional Climate Center* – **http://www.wrcc.dri.edu/**
  WRCC houses all historic data from RAWS stations.
- *High Plains Regional Climate Center* – **http://www.hprcc.unl.edu/**
  HPRCC contains historic NWS weather station data from parks in North Dakota, South Dakota, and Nebraska.
- *MesoWest* – **http://www.met.utah.edu/mesowest/**
  This site houses data from weather stations across the U.S., including RAWS and NWS stations. One of the most unique features of this website is an interactive surface weather map.

Internet weather sites specific to each park including the National Weather Service are listed below. If a weather station is not listed for the park, the closest alternative was mapped. A list of contact information for the National Weather Service serving each park is listed in SOP 9. That list maybe used to request spot forecasts.

EFMO and HEHO
www.dnr.state.mn.us/forestry/fire/index.html
http://www.crh.noaa.gov/arx/?n=firewx (LaCrosse)
http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?sdWBOS

TAPR
http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?sdKTAL
http://www.hprcc.unl.edu/stations/index.php?action=metadata&network_station_id=148061
http://www.crh.noaa.gov/top/ (Topeka)

HOME
http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?sdNRAI
http://www.crh.noaa.gov/oax/ (Omaha)
http://www.hprcc.unl.edu/stations/index.php?action=metadata&network_station_id=250622

PIPE
http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?sdMRDS
http://www.hprcc.unl.edu/stations/index.php?action=metadata&network_station_id=216565
http://www.crh.noaa.gov/fsd/ (Sioux Falls)

WICR and GWCA
http://www.raws.dri.edu/cgi-bin/rawMAIN.pl?sdMMTV (Mt. Vernon station)
http://www.crh.noaa.gov/sgf/ (Springfield)

Fire Danger Rating

The various factors of fuels, weather, topography and risk are combined to assess the daily fire potential for an area. Fire danger is usually expressed in numeric or adjective terms. Fire danger ratings are typically reflective of the general conditions over an extended area, often tens of thousands of acres, relevant to a new fire. Ratings can be developed for either current (observed) or future (predicted) situations. They can be used to guide decisions two or three days in advance (subject to the limits of the forecasting system) as well as to compare the severity of one day or season to another. Fire danger ratings describe conditions that reflect the potential for a fire to ignite, spread and require suppression action over a large area.

Two indices, burning index (BI) and energy release component (ERC), are used to determine staffing levels. Staffing Levels are expressed as numeric values where 1 represents the low end of the fire danger continuum and 5 the high end.

Burning Indices

The Burning Index is a number related to the contribution of fire behavior to the effort of containing a fire. The BI (difficulty of control) is derived from a combination of Spread Component (how fast it will spread) and Energy Release Component (how much energy will be produced). In this way, it is related to flame length, which, in the Fire Behavior Prediction System, is based on rate of spread and heat per unit area. However, because of differences in the calculations for BI and flame length, they are not the same. The BI is an index that rates fire danger related to potential flame length over a fire danger rating area. The BI is expressed as a numeric value related to potential flame length in feet multiplied by 10. The scale is open-ended which allows the range of numbers to adequately define fire problems, even during low to moderate fire danger.

Energy Release Component

The Energy Release Component is a number related to the available energy (BTU/per ft^2) within the flaming front at the head of a fire. Daily variations in ERC are due to changes in moisture content of the various fuels present, both live and dead. Since ERC represents the potential "heat release" per unit area in the flaming zone, it can provide guidance to several important fire activities. It may also be considered a composite fuel moisture value as it reflects the contribution that all live and dead fuels have to potential fire intensity. The ERC is a cumulative or "build-up" type of index. As live fuels cure and dead fuels dry, the ERC values get higher thus providing a good reflection of drought conditions. The scale is open-ended or unlimited and, as with other NFDRS (National Fire Danger Rating System) components, is relative. Conditions producing an ERC value of 24 represent a potential heat release twice that of conditions resulting in an ERC value of 12. Since wind and slope do not enter into the ERC calculation, the daily variation will be relatively small.

Photographs

Photo documentation of monitoring plots, monitoring itself, and burn events are invaluable. Pre- and post-burn images can be compared to visually recognize structural changes through time, burn completeness, burn severity, and fire behavior, etc. Pre- and post-burn photographs of transects are taken in a systematic way using flags for plot recognition and a white dry erase board to label the plot and burn status in the image. A field notebook is kept with the camera to record each image and its contents immediately after taking the picture. In addition to transect images, photos may be taken whenever there is something interesting to photograph. It is useful to have photographs of fire behavior, smoke, firefighters working on the line, etc. Photos are stored on the HTLN server in the fire folder. Further detail on field photography is described in SOP 4.

Fuel Moisture Sampling

Fuel moisture contributes to fire intensity and fire severity. Although grasslands consist primarily of 1-hr fuels, we collect 10-hr fuel moisture using the standard 10-hr fuel moisture sticks (allowing for on-site assessment), as well as 1-hr fuels by clipping. Ten-hr fuel sticks are read and reported to the burn boss on burn day, but 1-hr samples cannot be dried until after the burn occurs; and, therefore, are reported in the fire report and primarily used for interpretation and analysis. A 0.01-m^2 hoop is used for collecting 1-hr fuels, and 3-4 samples are collected per site. Samples are put in an airtight container to avoid moisture loss and weighed immediately. A detailed description of protocols and a datasheet are included in SOP 5.

Fuel Load

Fuel load is a key component to writing appropriate burn prescriptions and predicting fire behavior. The amount and type of fuels (lag class) present in conjunction with the state of those fuels (moisture, packing) determine fire behavior and intensity. This project encompasses both woodland and grassland fuel models and sampling methods vary accordingly. In the event that a site transitions from grassland to woodland or vice versa, change of sampling protocol to the current community type should be discussed.

<u>Downed Woody Fuel Load</u>

Downed woody fuel load of forested areas is estimated by using the planar intercept method (Brown et al. 1982). Fuels transects are associated with long-term vegetation monitoring sites or virtual sites within burn units. Woodland fuel loads are collected at WICR, EFMO, HOSP, and PERI as part of the plant community monitoring. However, additional monitoring of woodland fuels at WICR and EFMO will be collected by the fire ecology crew in conjunction with prescribed fires (pre- and post-burn). The fire ecology crew will coordinate with the HTLN Plant Ecologist to ensure pre- and post-fire fuels measurements are collected. For additional details and a datasheet on measuring downed woody material, refer to SOP 6, the Fire Monitoring Handbook (NPS 2003), and Brown et al. (1982).

Grassland fuels-in situ
Fuel load in grassland areas is estimated by clipping vegetation from a known area to determine tons/acre of grassy fuels. Ideally, fuel samples would be collected during the growing season before a prescribed fire is scheduled. This would allow for fuel load calculations to be available to operations staff at the time of the burn. However, for logistical considerations, fuel load samples are collected shortly before the burn and loadings reported in the post-burn report. Four samples are collected near each vegetation monitoring site or virtual site in scheduled burn units. Loadings are averaged per site and scaled up to either burn unit or park scales. (See SOP 7)

Grassland fuel -*photo board method for use with special projects only* (TAPR only)
An indirect measurement of biomass has been tested for accuracy at TAPR. This method involves taking a picture of a white board from a known distance and height. The image was calibrated against clipped biomass and a calibration curve produced. Future sampling will not require clipping, only photography. The calibration curve is more accurate at <1 and 1 years since burn than at ≥ 2 years (Leis and Morrison 2011). While this is not the preferred method, it may have application for special projects in the future. See SOP 7.

Soil Moisture Sampling
Although not to the extent of fuel moisture, soil moisture content can affect the severity of a burn by removing energy from the fire and contributing moisture to litter and duff layers. Soil moisture sampling (gravimetric method) is most often done in conjunction with biomass sampling by collecting a soil sample from within a circular frame after the herbaceous material has been removed. Although soil type can affect moisture holding capacity, HTLN monitoring sites are stratified by soil type to alleviate this effect. An electronic meter reporting volumetric water content is the preferred method. The meter is the preferred tool because it is less invasive, and allows for immediate reporting on burn day. Previously, gravimetric methods were used and data can be converted to a volumetric format. If the meter fails, gravimetric methods may be substituted. See SOP 8.

Level 2: Fire Observation
Fire Ecologists often serve as Fire Effects Monitors (FEMOs) on prescribed and wildland fires. The primary responsibility of a FEMO is to make observations of the fire. Monitoring fire conditions includes data on ambient conditions and fire and smoke characteristics. These data are coupled with information gathered during environmental monitoring to predict fire behavior, identify potential problems, and understand fire ecology.

Fire Weather
FEMOs are responsible for measuring, recording, and broadcasting weather observations throughout a burn period. This often includes requesting a spot weather forecast for the project area at the beginning of the operational period. Spot weather requests are generally made on the internet but can be done over the phone when necessary. Spot weather forecasts are prepared for GWCA and WICR by the Springfield office, EFMO and HEHO are prepared by the LaCrosse office, PIPE is prepared by the Sioux Falls office, TAPR is prepared by the Emporia office, and Home is prepared by the Omaha office. The lead FEMO usually reads the spot weather forecast at the briefing at the beginning of the operational period. The burn boss or incident commander should inform the FEMO how often to make and broadcast weather observations. The radio frequency used to broadcast the observations should be established during briefing. This is

commonly done once an hour and broadcast over the command frequency. SOP 9 contains a fire weather datasheet as well as a spot weather forecast evaluation form.

Fire Behavior

Fire behavior contributes to fire intensity and impacts of a fire. Variables such as flame height and depth are central to understanding the position of the fire relative to critical features of plants such as growing points. To the extent that is it is safely possible, rate of spread, flame length, and flame depth are recorded. See SOP 10.

<u>Rate of Spread</u>

Rate of Spread (ROS) describes the fire progression across a horizontal distance, and is measured as the time it takes the leading edge of the flaming front to travel a given distance. ROS is expressed in chains/hour, but it can also be recorded as meters/second.

<u>Flame Length</u>

Flame length is the distance between the flame tip and the midpoint of the flame depth at the base of the flame—generally the ground surface, or the surface of the remaining fuel (Figure 2).

<u>Flame Depth</u>

Flame depth is the width, measured in inches, feet or meters, of the flaming front (Figure 2). Measure the depth of the flaming front by visual estimation.

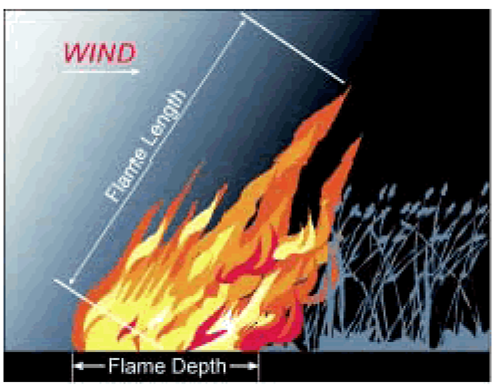

Figure 2. Graphical representation of flame length and depth.

Smoke Monitoring

Smoke observations are made throughout the burn period and include information about the smoke column and visibility in the vicinity. Photos may also be taken as additional documentation of conditions. See SOP 11.

Fire Progression/Ignition Pattern

FEMOs work closely with ignition teams to document fire progression and ignition patterns throughout a prescribed fire. This information is provided in the fire report for the incident. Ignition patterns can affect a fire's effect on the vegetation, especially if the unit is burned the same way every time. Therefore, documentation of the fire progression can help to explain differences in plant communities across a burn unit. See SOP 12.

Immediate Post-burn Assessment

Post burn assessments include measuring burn severity, re-measuring fuel loads, and documenting the actual area burned (SOP 13). Burn severity is assessed and photos are taken for all sample sites in burn units. Burn severity is rated and coded separately for organic substrate and vegetation. Woodland and grassland sites are treated slightly differently (see below). Downed woody fuels are also re-measured during the immediate post-burn visit using the same protocol as for pre-burn fuels.

Woodland severity

Woodland sites are generally visited within two to three weeks following prescribed fire. This allows time for impacts to overstory trees to become visible. Burn severity is recorded at the same points on the Brown's lines where litter and duff are measured. At each sample point, burn severity to the organic substrate and to above-ground plants in a 0.10-m^2 area (circular hoop) is evaluated. Also evaluate severity on the vegetation monitoring transects at 3-m intervals, using the same staggering technique as for vegetation monitoring (A line starts at 3 m, B-line starts at 0 m). Use the burn severity coding matrix included on the datasheet to determine the severity ratings.

Grassland severity

Grassland sites are often visited the day after a fire or even the same day as the fire. Severity is assessed on the HTLN long-term monitoring vegetation community sites at 3-m intervals in a 0.1 m^2 area (circular hoop). The severity data may be used to coarsely estimate the amount of fuel consumed in the fire.

Documenting burned area

In the past, the burned area was assumed to be the entire area of the ignited unit. However, more detailed mapping of burned area of attempted units is more useful for interpreting fire effects. Staff use GPS units to map the precise border of the burned areas (SOP 3). By documenting burned area, monitoring trends can be evaluated for their relationship with fire. Mapping the burn area is a shared responsibility between park and HTLN staff and depends on logistics, size of the burned area, etc. Techniques for documenting the actual area burned can vary depending on the size of the burn unit, completeness of the burn, and visibility of the landscape. This data will be used to update the Fire Occurrence geodatabase. See SOP 3, section III. Opportunities to map the burned units using remote sensing techniques in these parks are limited because of small burn acreages. Furthermore, it is more difficult to detect burn scars in grassland areas than woodland areas.

Prescribed Fire Monitoring Report

The HTLN Fire Ecology Program and FEMOs are responsible for writing prescribed fire monitoring reports following each prescribed fire. The main purpose of this report is to document detailed information regarding fire observations and fire conditions. Fire managers often need a summary of this information immediately following a fire. This information may be used to refine prescriptions, strategy, and tactics over both the short- and long-term. The report will utilize the National Reporting Data Report (NRDR) template found at: http://www.nature.nps.gov/publications/NRPM/NRRNRTR.cfm. The content will incorporate the elements recommended in the Fire Monitoring Handbook, page 16. The elements are also listed in SOP 14 (USDI National Park Service 2003). Completed reports are posted on the HTLN server and website and given to the appropriate FMO, burn boss, park natural resources manager, and regional fire ecologist.

Data Management

Effective data management allows the project leader to store and retrieve large quantities of data securely and efficiently. Data management typically becomes an issue when the number of records surpasses the range of 10^4 to 10^5. Procedures for quality control are also needed to ensure accuracy in data entry. This project maintains databases for numerical sampling data in FEAT FIREMON Integrated (FFI), and spatial data in file geodatabase format.

Overview of Database Design

Fire ecology data is entered and held in a standard FFI database. It is the current standard for NPS fire effects monitoring teams. This database is freeware available from http://frames.nbii.gov/. It is based on a Sequel Server Express platform and is supported on an interagency level. For a detailed description of the database design see http://frames.nbii.gov/ffi/docs/FFI_Overview.pdf. The Fire Ecologists computer serves as the master for the database and the lead monitor is able to remotely access the master for data processing. All appropriate permissions and firewalls are in place to protect data security. The lead monitor has primary responsibility for data entry. Data is error checked and stored according to HTLN protocols (Rowell et al. 2005). Backups are frequently created and stored within HTLN systems as well as annually at the NPS Midwest regional office. Spatial data are retained in a geodatabase and shared with parks and the NPS regional fire spatial analyst after updates occur.

Data Entry

A number of features have been designed into FFI to minimize errors during the data entry process. Sample site names are equivalent to those used in the HTLN Vegetation Monitoring database. Standardized identifiers for sample location and sample date are selected from choices provided by the user interface. Sampling methods are assigned to each park and then selected during data entry. Data entry fields are standardized for interagency use and remain unmodified. Consequently, only valid names or measures may be entered and spelling mistakes are eliminated. Specific instructions for data entry are given in SOP 15.

Data Verification and Validation

Data verification immediately follows data entry and involves checking computerized records against the original source, usually paper field records. Once the computerized data are verified as accurately reflecting the original field data, the paper forms are archived and the electronic version is used for all subsequent data activities. Data validation involves checking the accuracy of data against independent controls or specifications. More details regarding the verification and validation process are located in SOP 15.

Staff Roles and Responsibilities

Although the lead monitor will be responsible for data entry (FFI), the fire ecologist is responsible for data quality. The fire ecologist must ensure data quality throughout the process of data entry, data verification, and data validation. The HTLN data manager is responsible for secure backups of all project data. A team of interagency data managers assists with database development and function. A Google Groups site (http://groups.google.com/group/FFIemu?hl=en) is available as a forum for discussing database modifications and errors.

Geographical Information System (GIS)

HTLN spatial fire data are stored in two geodatabases that are housed on the HTLN servers. One geodatabase contains the historical record of burned areas for each park (referred to as "fire occurrence" data). The other geodatabase contains any additional spatial information that is related to the monitoring of fire effects (e.g., locations of fuel moisture sticks). Fire occurrence data from the Wildland Fire Management Information (WFMI) system were validated with data provided in Fire Management Plans, and discussion directly with parks. This record will be maintained as a repository of regional data. Other spatial data that are relevant, such as topographic maps, vegetation maps, boundaries, roads, etc. for HTLN parks are also stored on the HTLN server. The HTLN GIS specialist is responsible for the storage of all spatial data.

Global Positioning System (GPS)

A GPS unit will be used to navigate or collect spatial data. TerraSync™ Professional software is used on the GPS units. The GIS specialist is responsible for loading/unloading data for the GPS units. For navigation purposes, a background file containing an image, boundaries, and transportation for the park, as well as any site waypoints will be loaded. For data collection purposes a data dictionary will also be loaded on to the GPS unit. The data dictionary should be used for all data collection to decrease the chance of errors. For more information on specific GPS settings and usage, refer to SOP 3.

Analysis and Reporting

Core data analyses will follow recommendations in the Fire Monitoring Handbook (USDI National Park Service 2003). Primary analyses will focus on specific objectives as outlined in the Fire Monitoring Plans and/or Prescribed Burn Plans for each specific park or burn. Analyses will focus on determining whether these objectives have been reached. Most objectives will be stated in terms of a percentage range of reduction in some variable (e.g., reducing fuel load 50 – 70%) or a goal of obtaining a percentage range of some variable (e.g., reducing shrub cover to 5%). In such cases, the mean change or the mean value of the variable will be calculated, along with appropriate confidence intervals, to determine whether the goal has been met. (See USDI National Park Service 2003 for examples.)

As our ability to define desired long-term threshold values or ranges improves (as opposed to short-term goals for change), a control chart approach may be the most appropriate way to evaluate the data. Means and confidence intervals would still be constructed for the data collected, and control limits would represent desired management thresholds or ranges. (See Morrison 2008 for a description of the application of control charts to ecological data.)

At Tallgrass Prairie National Preserve (TAPR), fire is used as a management technique in an attempt to alter vegetation structure, and is part of an overall patch burn grazing strategy. Additional analyses may be desirable at TAPR to evaluate the success of the patch burn grazing program. Analyses should be tailored to specific management goals or questions.

Finally, the environmental variables for which data are collected (i.e., soil moisture, fuel moisture, weather, etc.) could be useful in understanding why goals were or were not met. A large number of analyses—including both univariate and multivariate approaches—could be applied, depending upon the question. Since this issue is not a core goal of the analyses, and would be done post-hoc, we do not describe all the possibilities here. A qualified analyst should be consulted, and the specific questions outlined, prior to analyses regarding these variables.

Reporting

To facilitate timely dissemination of monitoring results, fire reports are completed within three months post-fire (SOP 14). Fuel load status reports are provided to parks by January 31 each year. More extensive analyses and reporting are done coincidentally with the four-year cycle for vegetation monitoring reports. Synchronizing the fire ecology report with vegetation monitoring will provide additional insight into long-term trends. Report formats will follow the established and most current format of the NRTR style. Each report will be assigned a TIC number and be made available in electronic format on the HTLN website (http://science.nature.nps.gov/im/units/htln).

Operational Requirements

Annual Workload and Field Schedule

Monitoring will require at minimum a two-person crew each year, but a crew of three to four people is ideal. Field person days are dependent upon the number of parks conducting burns, logistics, weather, and crew skill level. Table 2 describes the sample procedures currently employed. Each of the procedures is described in detail in the SOPs.

Knowing the distribution of workload throughout the year is helpful for planning. Certain project activities are predictable, especially administrative ones. Although the majority of prescribed fires have occurred in the spring, it is likely the burn season will vary in the future requiring Level 1 & 2 monitoring throughout the year. The general annual work plan described below takes into consideration the most likely times of year burns will occur.

Generalized annual work plan

January-March
Train staff.
Meet with park liaisons and FMOs.

March-May
Participate in prescribed fires.

June
Data entry and database management.
Assist with vegetation vital signs monitoring field work as needed.
Obligate funds as needed.

July
Assist with vegetation vital signs monitoring field work as needed (EFMO).
Write end of year report for MSU.

August
Conduct photo board sampling at TAPR.
Participate in fall burns.
Prepare for biennial meeting.

September
Complete all data entry and quality control activities.
Write end of fiscal year report for HTLN.
Plan for equipment needs.
Participate in fall burns.

October-November
Participate in fall burns.
Work on planning and analysis/reporting projects.

December
Write end of year report for NPS Fire Ecology.
Distribute current data on fuel loads to parks.
Update protocols.
Evaluate program and project funding and submit grant proposals.

Table 2. List of fire ecology procedures being deployed.

Procedure	Year Initiated 2008	2009	2010	Comments
Pre- and post-burn photographs of field sites		X		
Soil moisture		X		
Fuel moisture			X	In addition to 10-hr sticks.
Fuel load woodland		X		
Fuel load grassland		X	X	TAPR and WICR, 2009, photoboard
Post-burn severity (ground level)		X		
Burned area mapping (gps)		X		
Weather recording		X		
Fire report development		X		
Fire occurrence geodatabase	X			

Personnel
Fire ecology work is lead by the HTLN Fire Ecologist. A lead monitor and one crew member also support the program. The regional fire ecologist provides guidance in program development, funding, and communication with regional personnel. Staff needs are dependent upon the number of fires and samples required at each event. After sufficient data are collected, sample size should be evaluated and crew size adjusted accordingly.

Training Requirements
To participate on Federal fires, personnel must have a valid red card. To acquire a red card, class work (S130/S190/I100/L180) must be completed. In addition, staff must complete a pack test (3 mile walk carrying 45 lbs/45 min) and refresher training annually (http://www.nwcg.gov/pms/docs/docs.htm). Fire qualifications will be communicated to both Missouri Department of Conservation (MDC) Fire Training Coordinator and NPS regional fire training database manager in Omaha. Missouri State University staff records will be maintained and cards issued primarily through the State of Missouri MDC office, while NPS staff records will be maintained through the NPS Midwest Regional Office. Staff will also complete CPR, first aid, and defensive driving training as per existing HTLN safety protocols (Cribbs 2008). Specific sampling protocol training will be offered either prior to the field season or on the job.

Facility and Equipment Needs
The nature of fire ecology monitoring work does not require special facilities for office space. Specialized personal protective equipment (e.g., Nomex clothing, hard hat, gloves, fire shelter) is obtained through a combination of sources. If the fire cache at the Ozark National Scenic Riverways or Midwest Regional Office are unable to supply needed equipment, the items will be purchased with local funds. Field sampling equipment is obtained through the HTLN cache or purchased with the fire ecology budget. A list of field equipment needs for one crew can be

found in SOP 1. Both office space at Missouri State University and a shed at the host park, WICR, serve as locations for field equipment storage.

Budget

Additional costs such as office supplies and vehicles are provided directly from HTLN annual operating budgets and are not accounted for below. HTLN has also funded a Student Conservation Association volunteer through the use of Fuels Reserve Funds (Table 3).

Table 3. Generalized budget

Budget Item	Description	Cost (1-year)
Fire ecologist salary (~GS11)	$4708.33/month	$ 56,499.96
Benefits	45%	$25,424.98
Lead monitor salary (~GS7)	$2958.30/month	$ 35,499.60
Benefits	45%	$ 15,974.82
Field work travel	$3000 each ecologist, lead	$ 6,000.00
Other travel (meetings, etc.)	$1500 each ecologist, lead	$ 3,000.00
SCA volunteer (stipend, housing, travel)		$ 35,000.00
PC/network monthly fee	$5/month each person	$ 180.00
Phone monthly fee	$20/month two phones	$ 480.00
Transportation (MSU motor pool)	$0.42/mile + $20/day	$ 2,000.00
Equipment		$ 2,000.00
Total		$182,059.36

Procedures for Revising the Protocol

Over time, revisions to the protocol narrative and to SOPs are to be expected. Careful documentation of changes to the protocol and a library of previous protocol versions are essential for maintaining consistency in data collection and for appropriate treatment of the data during data summary and analysis. The FFI databases and/or geodatabase for each monitoring component contain a field that identifies which version of the protocol was being used when the data were collected. The rationale for dividing a sampling protocol into a protocol narrative with supporting SOPs is based on the following:

- The protocol narrative is a general overview of the protocol giving the history and justification for the work and an overview of the sampling methods, but does not provide all the methodological details. The protocol narrative will only be revised if major changes are made to the protocol.

- The SOPs, in contrast, are very specific step-by-step instructions for performing a given task. They are expected to be revised more frequently than the protocol narrative.

- When a SOP is revised, in most cases, it is not necessary to revise the protocol narrative to reflect the specific changes made to the SOP.

- All versions of the protocol narrative and SOPs will be archived in a protocol library.

The steps for changing the protocol (either the protocol narrative or the SOPs) are outlined in SOP 17, “Revising the Protocol”. Each SOP contains a revision history log that should be filled out each time a SOP is revised to explain why the change was made and to assign a new version number to the revised SOP. The new version of the SOP and/or protocol narrative should then be archived in the HTLN protocol library under the appropriate folder.

Discussion

Fire is an important ecological process for several parks within the Network. The effects of fire are far reaching within both grassland and woodland systems. For example, burning can affect plant species composition and density, soil nutrient cycling and wildlife, in addition to mitigating hazardous fuel loads. (Bragg and Hulbert 1976, Ladd 1991, Bragg 1995, Johnson and Matchet 2001, Gaetani et al. 2010). National parks are working to develop goals and objectives for ecosystem management with respect to fire and these variables. Monitoring is an integral part of evaluating the status of these goals and objectives.

This protocol is the result of integrating the Fire Monitoring Handbook (USDI National Park Service 2003) with the existing monitoring infrastructure of HTLN. Although the majority of ecosystems in the parks the HTLN fire ecology program focuses on are tallgrass prairie, other glade and woodland communities exist. Hence, the SOPs were developed using a combination of the Fire Monitoring Handbook (USDI 2003), the National Park Service standard for fire ecology monitoring, and the current HTLN vegetation monitoring protocol (James et. al. 2009). The SOPs cover preparation, training, sampling, data management and analysis, reporting, and protocol revision procedures.

The SOPs contain standardized approaches for field sampling and data processing to reduce errors and increase accuracy. If monitoring outside of the standard set of SOPs is needed, a new SOP will be written to satisfy that need. The SOPs herein are described in a logical order to facilitate use. Some SOPs include modified methods depending on whether the site is a grassland or woodland community (Figure 3). SOPs 1 through 3 contain preparatory information, use of GPS units, methods for establishing temporary monitoring sites and a field task list. Because several sampling techniques may be applied within a given site visit, the field sampling task list can assist monitors in making sure all monitoring is completed in an appropriate order. SOPs 5 through 8 include pre-burn monitoring methods. SOPs 9 through 12 include monitoring that is conducted during the burn itself. These protocols serve an immediate purpose of making sure the burn is completed safely, but also on a more long term basis as environmental variables available for multivariate analyses. SOPs 13 and 14 include monitoring that is completed immediately post burn. Assessment of ground level fire severity and spatial recording of the burned areas are important for understanding the extent and intensity of the burn. SOP 15 describes post-burn reporting. This report focuses on the short-term fire effects while technical reports will address longer-term trend analysis. The remaining protocols provide a standard format for data and protocol management.

This fire ecology monitoring program has developed an innovative approach. It is a collaborative effort between several departments such as Inventory and Monitoring, NPS-Fire, and NPS-Fire Ecology, as well as Missouri State University. We felt that the development of the program may be useful to others interested in a similar approach so we have included both an administrative history as well as a five-year plan in appendices.

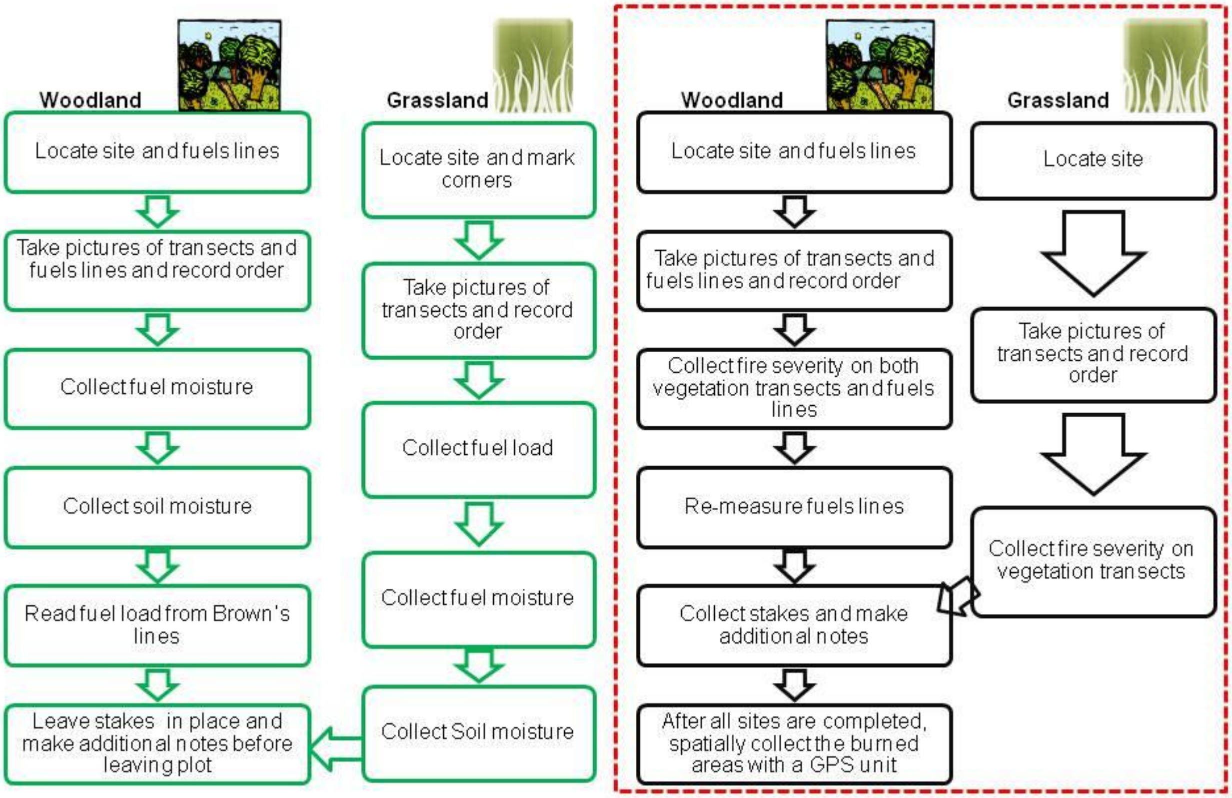

Figure 3. Work flow diagram. Grassland and woodland tasks on the left are prescribed for pre-burn status. Tasks outlined on the right in a dashed box are prescribed for post-burn status.

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Standard Operating Procedures

Fire Ecology Monitoring Protocol
For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 1: Preparations and Equipment Setup Prior to the Field Season

Version 1.00 (02/01/2011)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP provides information to prepare for the field season, including a list of field equipment needed.

I. General Preparations

Prior to the field season each year, usually beginning in February, all observers should review the entire protocol, including SOPs. Refreshing knowledge of weather observation and radio communication is particularly important, as is reviewing the standard sampling procedures implemented at each monitoring site. The following list includes key points to consider in preparing for the upcoming field season.

A field notebook for the survey year should be prepared with pages for entry of sampling schedules, observer names, field hours, and unique happenings that may influence how the data are reported. Information included in trip reports is based on what is recorded in field notebooks, so it is imperative that they are clearly organized for ease of field note entry.

The equipment inventory should be updated and equipment organized and made ready for the field season several weeks prior to the first sampling trip. This allows time to make needed repairs and order equipment. The following is a list of field equipment needs for one crew; if two or more crews work simultaneously, equipment needs will change accordingly (Table 1).

A packet of necessary field data forms, park maps, and copies of datasheets from previous seasons should be assembled prior to the field season. A packet should be assembled for each park and properly labeled. Maps should include an overview of the park for navigation as well as zoomed in map(s) of sampling sites if needed. Overview park maps are included for reference in

Table 1. Equipment needed for fire ecology work. Items correspond closely to SOPs.

	Task								
Equipment	**Personal fire gear**	**Geospatial and virtual site**	**Fuel moisture**	**Soil moisture**	**Downed Woody Fuel Load**	**Grassland fuel load**	**Immediat post-burn--severity**	**Immediate post-burn--spatial**	**Site maintanence**
Appendix B (NIFC)	X								
Camera and spare batteries/storage card	X	X			X		X		
Compass	X	X	X	X	X	X	X	X	
Fire day pack	X								
Fire radio/chargers/cloning cable/spare batteries and clamshell	X	X	X	X	X	X	X	X	
Food (not provided)	X								
Gear bag	X								
Hard hat	X								
Head lamp	X								
Hydration system (not provided)	X	X	X	X	X	X	X	X	
Leather boots, 8" to the ankle with Vibram soles	X								
Leather gloves	X		X			X			
New generation fire shelter	X								
Nomex pants	X								
Radio harness	X								
Safety glasses	X								
Stop watch	X								
Yellow fire shirt	X								
0.01 m^2 hoops			X	X					
0.10 m^2 hoop						X	X		
50 ft tapes (4 plus backup)		X			X		X		
50 m tapes (2 plus a back up)		4 tapes	X	X		X	X		
Belt weather kit including Kestrel	X	X	X	X	X	X	X	X	
Chaining pins (8)		4			4	4	4-8		
Clinometer		X			X				
Clip boards and pencils	X	X	X	X	X	X	X	X	
Data sheets		X	X	X	X	X	X		
Drying oven			X	X		X			

Table 1. (continued)

Equipment	Personal fire gear	Geospatial and virtual site	Fuel moisture	Soil moisture	Downed Woody Fuel Load	Grassland fuel load	Immediat post-burn--severity	Immediate post-burn--spatial	Site maintanence
Electronic scale			X	X		X			
Flagging		X			X				
Fuel moisture scale for 10-hr sticks			X						
Fuels gauge			X		X				
GPS unit and backup unit		X	X	X	X	X	X	X	
Graduated trowel					X				
Grass hooks			X			X			
Mallet									X
Maps	X	X	X	X	X	X	X	X	
Metal detectors and spare batteries		X	X	X	X	X	X		
Monopod and clips			X						
Paper bags						X			
Photoboard									
Pin flags (8)		4			4	4	4-8		
Protimeter and spare battery			X						
Retractable washline									
Ruler, 10 scale, clear					X				
Shears			X			X			
Spare rebar									X
Spare yellow caps									X
Tins, large			4/site						
Tins, small				3/site					
Trowels				2					
White board and marker		X					X		

Appendix 1. Data sheets for different SOPs can be copied using differently colored paper for ease of recognition and use in the field.

II. *Circular Sampling Frames*

The circular frames used for fire ecology sampling are 0.1 m^2 and 0.01 m^2. They are made of hollow PVC tubes and are held together by PVC threaded connectors. Table 2 lists the dimensions necessary for the construction of each circular frame. Each frame is formed into a circle, joined with a connector. For the 0.01 m² frame, a large metal hose clamp can be used, instead of a PVC tube. Throughout the field season, a minimum of two frames should be in good working condition. It is highly recommended that flagging be tied to the hoops to keep them from getting lost.

Table 2. Circular plot dimensions

Plot size	Length of PVC tube	Additional parts
0.01 m^2	0.35 m	PVC connector
0.1 m^2	1.12 m	PVC connector

Fire Ecology Monitoring Protocol
For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 2: Field Sampling Tasks

Version 1.00 (02/01/2011)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP provides an overview of the sampling techniques and order of deployment pre-burn and post-burn for both woodland and grassland monitoring. The following SOPs provide detail on how to conduct each sampling technique. The diagram below (Figure 1) describes the flow of field sampling for both grassland and woodland ecosystems in either pre-burn or post-burn settings. It could be pasted into field notebooks for easy reference.

Crew size for the HTLN fire ecology field work is typically three people. To make the most efficient use of personnel, recommendations for task assignments are the following:

Pre-burn Woodland

Two people take site pictures while one person begins taking fuel moisture samples. When the pictures are completed, one person begins soil moisture while one person becomes a recorder. On fuels lines, one person records for one reader, and the other reader will record for self.

Pre-burn Grassland

Two people take site pictures while one person begins clipping for fuel load. When the pictures are completed, the other two begin fuel and soil moisture sampling with one designated as recorder.

Post-burn Woodland

Two people take site pictures while one person begins reading fuels lines. When pictures are done, one person assists with reading fuels lines by reading unread lines. The third person records for one reader.

Post-burn Grassland

Two people take site pictures while the third begins reading severity. The other two then assist with severity collection with one person serving as a data recorder.

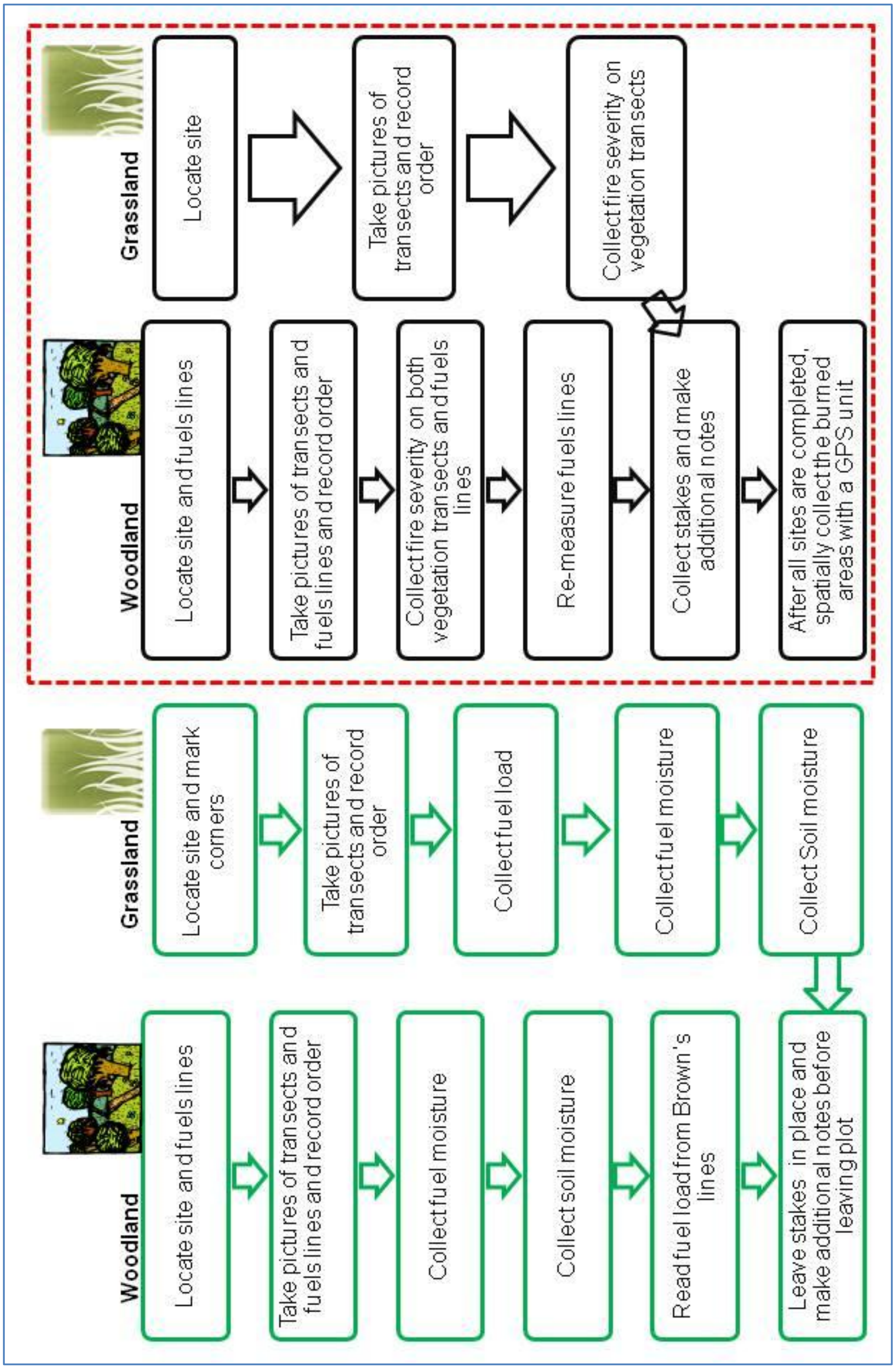

Figure 1. Work flow diagram for field sampling. Grassland and woodland tasks on the left are prescribed for pre-burn status. Tasks outlined on the right in a dashed box are prescribed for post-burn status.

Fire Ecology Monitoring Protocol
For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 3: Geospatial Data and Virtual Site Establishment

Version 1.00 (02/01/2011)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP describes the procedures for collecting site and burned area locations and how to navigate to sites. For specifics on how to use the GPS units, please see the document: Heartland Network GPS Operational Guide, located on the HTLN server. If you have any questions, contact the GIS specialist.

I. General GPS Settings

When a task requires the use of a GPS unit for either navigation or data collection, the following settings are required.

- System: UTM
- Datum: NAD 1983 (conus) CORS96
- Zone: 14N: HOME, PIPE and TAPR, 15N: EFMO, GWCA, HEHO, and WICR
- Altitude Measure: Height Above Ellipsoid (HAE)
- Units: Meters
- GPS Correction: set to real-time correction. Real-time correction may improve the accuracy of the GPS unit and at times may be called WAAS or SBAS.

All GPS files will be uploaded/downloaded by the GIS specialist, before and after field work. Remember to give the GIS specialist early notice before you sample about what park you are sampling, so they can prepare the GPS units for you.

II. Locating Sites

Primary monitoring plots chosen for fire effects work will be the HTLN plant community monitoring sites. Sometimes there will not be enough sites within the scheduled burn units to provide a valid sample. In that case, additional temporary monitoring sites (called “virtual sites”) will be established for that burn event. The HTLN breeding bird monitoring grid will serve as the basis for these temporary monitoring sites. The virtual sites will not be permanently marked.

Creating Virtual Sites

Once virtual sites are established, their locations and woody fuel line azimuths will not change. If the same unit burns in the future, then those locations and azimuths will be used to monitor fire.

1. In the office, open the software ArcMap. Inside ArcMap bring in the GIS data for the current burn units, breeding bird plots, and plant community sites. Knowing which units are scheduled to burn, check ArcMap to see if you have enough established plant community monitoring sites for your fire monitoring needs. No less than 3 plots, including plant community sites, should be chosen. Five to six plots would be a preferred sample size especially for larger units. If there are not enough vegetation sites, then you will have to create virtual sites, based on the HTLN breeding bird sites.

2. By using the ArcMap extension – NPS AlaskaPak – randomly choose the correct amount of breeding bird plots to fill out the 3-6 sites needed for sampling. Also, randomly select 3 backup breeding bird plots, in case one or more of the originally selected plots are not adequate. Breeding bird plots within 10 m of burn unit boundaries, trails, or roads should be avoided. Also, avoid plots on steep slopes or within riparian areas.

3. In the field, use a GPS unit to locate the breeding bird plot. This will serve as the NE corner of the plot whenever possible, (Corner AS). Transects should be laid out along the contours as in the HTLN Vegetation Community Protocol with the B-line being lower on the slope.

4. Mark the four corners with chaining pins, or other markers, for easier relocation post-burn. Collect the corner locations with a GPS unit and be sure to use the fire data dictionary provided. Nearby trees should be marked with flagging (as high up as possible) to aid relocation. Sample as indicated in this monitoring protocol.

   GPS collection specifics:

   a. First you must name the GPS rover file. For data management reasons, name the GPS rover file being collected with the park code, the year of collection and 'fire' (ex: wicrfire2011 or peri2011fire). In the rover file name, do not include spaces. All points that are collected for a park can be saved within the same rover file unless more than 5 days has elapsed since the start of data collection. If this has occurred, create a new rover file with the same name, but with a B, C, 2, etc. at the end.

   b. Sites will only be collected as point features. For each point a minimum of **50** positions should be collected at a **1 second** interval. While the positions are being acquired hold the GPS unit still over the rebar or marker being collected. If the GPS unit is moved or shifted during collection, which decreases accuracy, please recollect the point. The points themselves should be named with their site ID code. The site ID is 'F' followed by the site number and AS, AF, BS, or BF. The letter represents the transect line A or B, as well as the transect end S for start and F for finish (Ex: F3AS or F15BF). Completely fill out the data dictionary form on the GPS unit for each site. (Figure 1)

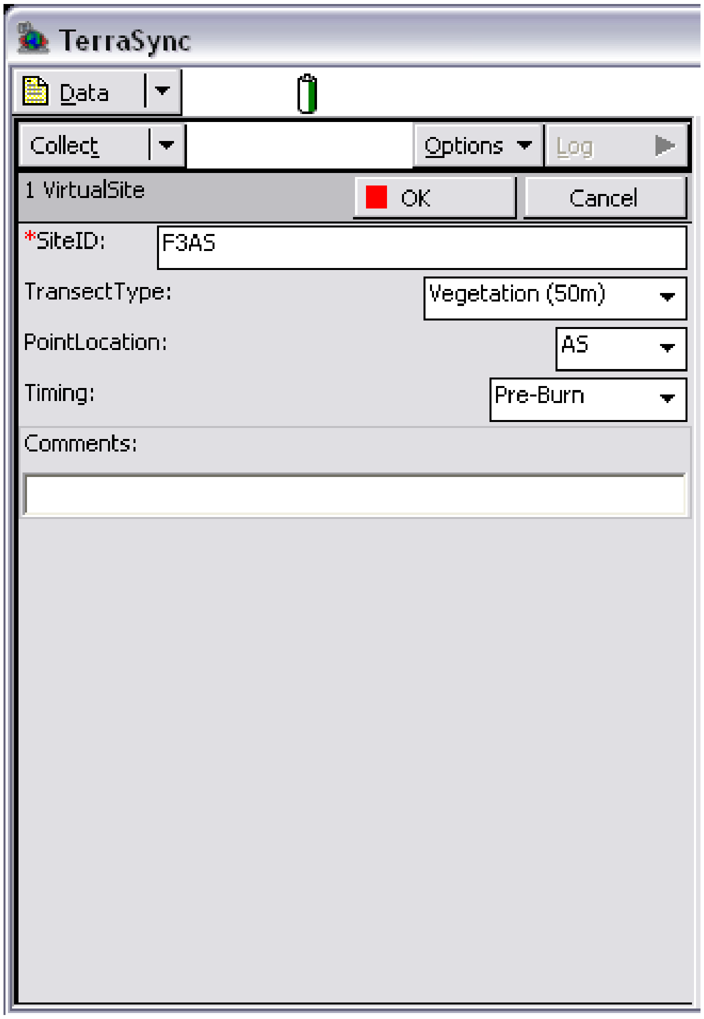

Figure 1. Virtual site data dictionary form.

a. When back in the office return the GPS unit to the GIS specialist for data processing.

5. Woody fuels transects (Brown's lines) should be established from the transect endpoints as per HTLN vegetation community protocol. Random azimuths should be generated prior to going to the field. Mark the ends of the fuels transects with chaining pins for easier relocation post-burn. Make sure to measure the transect's slope. Sample as in SOP 4.

6. Return to the site post-burn and complete sampling. Remove transect markers and flagging upon exit

Navigating to Sites
Before going out into the field, the GPS unit should be loaded with the waypoints needed for the sites being visited including both established vegetation sites and any new virtual sites. The GIS specialist is responsible for loading the waypoints onto the GPS unit.

III. Burn Polygons
After the burn has taken place, the areas that were burned need to be documented.

EQUIPMENT LIST
- GPS unit with data dictionary
- Hard copy map
- Sharpie or colored marker/pencil

Procedure
1. Assuming that the majority of the burn unit actually burned, it may be easiest to collect data on unburned areas. A minimum unburned area should be established prior to data collection. This may vary by burn unit size, but in general do not collect data on unburned areas less than 0.5 acre in size. If the burn unit is large, you may increase minimum acreages to 1 acre. The GPS unit should be preloaded with the data dictionary Figure 2).

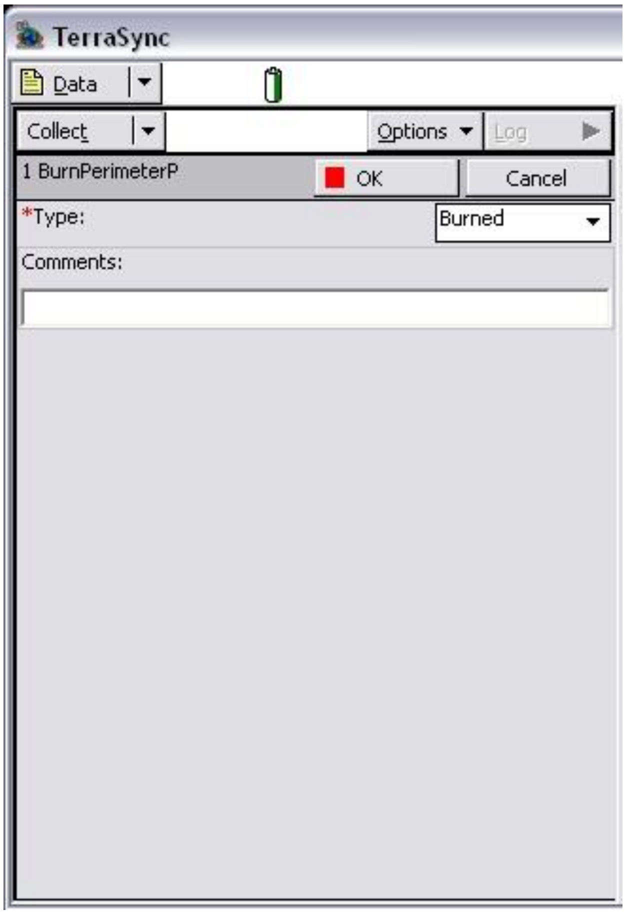

Figure 2. Data dictionary for burned area mapping.

2. If possible, collect polygon type features and indicate in the dictionary whether it was burned or unburned as well as other pertinent information. If the unit is large and heterogeneous, the data collector may prefer to collect point features along edges of burned areas or in a grid type fashion such that polygons can be drawn within the ArcGIS environment. Filling out the data dictionary is imperative. If lines are collected, indicate which side of the line has been burned.

3. It is important to draw on hard copy maps and take extensive notes as data is collected.

GPS Tips

*Make sure to collect all polygons in the same direction, either clockwise or counterclockwise. Using differing directions within the same file will lead to errors.

*Remember to avoid returning to your exact start point when collecting a polygon as it can lead to overshoots. Stop slightly before arriving at the starting point.

IV. Notes

It helps to allow the GPS unit to warm up for 5 – 20 minutes before you start navigating or collecting data. For warm up, turn the GPS unit on and open TerraSync™. Place the GPS unit somewhere will it will not get damaged, but in the open (not under canopy). Once you have 5+ satellites for more than a minute, proceed with navigation.

When not using the GPS unit for more than 10 minutes, turn the unit off to save battery power. **Make sure to close all software programs before turning the GPS unit off.** When the GPS is not being used, place the unit in an area out of harm's way and not in direct sunlight. Each GPS unit has a different battery life, look up what the life is for the unit you take out. Never allow the GPS unit to totally run out of power, as all data will be lost. Charge the GPS unit every night when in the field, but do not continue to charge the unit once the battery is restored to 100%.

In the event that the GPS unit will not give you a reading, check the *GPS plan* to see if it is just a bad time of day, due to the arrangement of satellites. If it is one of these times, the only thing to do is be patient and wait, this should correct itself in less than an hour. It is wise to check the *GPS plan* before leaving for the field, so this does not cause delays. If the plan indicates sufficient satellites, the GPS receiver may be blocked. Make sure your hand or other equipment is not blocking the receiver. A tree or hill can also block part of the horizon making it impossible for the GPS satellites signal to reach you. If you are collecting data, you will need to *offset* to collect your data. Go to an area where a GPS signal can be collect and offset back to the site by using a compass and rangefinder/meter tape. However, if you are navigating, also go to where a signal can be received and then guide the other members of your crew to the site location.

Please be familiar with the Heartland Network Operational Plan for GPS before going into the field. Each HLTN vehicle has a copy for reference. Finally, make sure to take all parts (e.g., chargers and external antennae) and hard case associated with each GPS unit when visiting a park and do not mix parts between units. Even though parts can look alike, at times they have different voltages that will cause harm when used with the wrong GPS unit.

V. Glossary

Features: Refers to what item is being collected – point, line or polygon.

GPS: Global Positioning System

PDOP: Position Dilution of Precision. It is an indication of the accuracy of the calculated position based on the location of the satellites in the constellation. If satellite positions do not allow the use of coordinate geometry, then accurate ground locations cannot be triangulated from them.

Positions: The number of signals received from the GPS satellites that are used to make a feature.

Post-processed Differential Correction: A method that reduces GPS measurement error by using base station data to correct the GPS rover file once field collection is done. (More accurate than real-time correction)

Real-time Correction: A method that reduces GPS measurement error by using WAAS (Wide Area Augmentation System) to correct the GPS on the fly.

Rover File: GPS file collected in the field.

UTM: Universal Transverse Mercator

Fire Ecology Monitoring Protocol

For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 4 –Photography

Version 1.00 (02/01/2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This protocol describes methods for documenting field conditions at monitoring sites, monitoring activities, and conditions during prescribed fires.

I. Equipment Needed

- Camera (Fuji F300 EXR) and accessories (charger, storage card). [A Canon Power Shot S40 was previously used.]
- Field notebook

II. Procedures

Transects

Pre- and post-burn photographs are systematically taken of each of the 50-m transects at each monitoring site. Flags are placed at each end of the transect so that the entire transect is identifiable in the picture. A white dry erase board is labeled with park code_site#, transect position (eg. Line A, start (AS)), date, and burn status. The camera should be set to Auto without flash. A picture of each transect should be taken with one person holding the dry erase board from the outside of the site. The board should be held close enough to the photographer so that the writing on the white dry erased board can easily be read in the picture. The board should be held at 1 m from the ground if at all possible. Fill the image with the transect and as much of the site as is feasible (as opposed to including the transect and area to the outside of the site). Capture the flags at both ends of the transect in the image, however in tall grass the flag at 50 m may not be visible. The image number and description should be recorded in a field notebook so that they can be properly labeled after download. Pre and post-burn photos should be taken in the same way. Additonal pictures of monitoring activities or interesting things in the field may also be taken. These pictures should also be recorded in the field notebook accompanying the camera.

Images should be downloaded as soon as possible after returning from the field. Download the images to a local computer and complete labeling prior to uploading to the HTLN server. Make a copy of the image folder and work on the copy. Image labels include park code_site, date (DDmonthYY), burn status, and transect position (e.g., HEHO16Apr09_PREBURN10ASAF).

Using the field notes, correctly and consistently label the images. Miscellaneous images should also be labeled in the same way, excepting the site name if irrelevant. Verify image labels, then upload labeled images to the HTLN server: N:\HTLN\Projects\HtlnMsu\Fire\Data\Photos and in a park specific folder. Finally, delete the unlabeled copies and images on the camera

Prescribed fire

In addition to transect images, photos may be taken whenever there is something interesting to photograph. It is useful to have photographs of fire behavior, smoke, firefighters working on the line, etc. If the opportunity arises to document a significant event on the fire, be sure to record the time and location of the photo as well as other information describing the event. The image and associated information will contribute to developing the fire progression map for the fire report. These photos are also labeled and stored on the HTLN server in the fire folder.

Fire Ecology Monitoring Protocol

For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 5 –Fuel Moisture Sampling

Version 1.00 (02/01/2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This protocol describes methods for sampling various fuels. A standard method of evaluating fuel moisture (10-hr fuel moisture sticks) will be employed as a means for obtaining instant feedback and a consistent reference across parks. More detailed sampling is needed for trend monitoring, however. The primary fuel types encountered in woodlands within HTLN parks are downed woody fuels and leaf litter. Measuring fuel moisture in grasslands requires a different method, because the primary fuel type of concern is 1-hr fuels composed of herbaceous plants. Duff can often be difficult to distinguish from litter and to collect in sufficient quantity. Furthermore, duff is often absent in grazed areas or rocky areas with little soil development. Therefore, we will avoid measuring moisture of the duff layer separately from litter.

I. Equipment Needed

- Pre-weighed containers. Aluminum tins with tight fitting lids will be used for fine dead and live samples.
- Shears. A sharp pair of hand shears for clipping needles and leaves.
- Data sheets.

II. Procedures

10-hr fuel moisture sticks

Equipment

One set of 10-hr fuel moisture sticks, two metal brackets, 10-inch ruler, grass clippers. A scale to measure the sticks, or additional sticks can be found at http://www.forestry-suppliers.com/product_pages/View_Catalog_Page.asp?mi=1554

Site Selection

The sticks should be deployed a minimum of two weeks prior to a prescribed fire. They can be deployed at any time prior to the minimum time period. It would be best to put them out when the sample site is clear of snow. The area should be relatively easily accessed for sampling, but be secure from visitor or cattle/bison tampering. It might be best to place the sticks in an area that is not planned to be burned or grazed that season to avoid burning up the sticks or destruction by curious cattle. The deployment site should be on a SW facing slope if the burn unit includes one, otherwise find a relatively level spot. Pick a site with fuels representative of the burn unit. In tallgrass prairie, if you can't find an interstitial space in the vegetation that is adequate, you may need to clip the grass so that it will not touch the sticks.

Deployment

Wear gloves and avoid touching the sticks with your bare hands as the oils can bias the measurements. Orient the holders North-South along the slope. Press the metal holders into the ground far enough apart to provide adequate support to the sticks. The brackets of the holders should be about 10 inches above ground when installed. If deploying the sticks on a slope, keep the sticks parallel to the slope, if possible. Record the date of deployment and collect a GPS point at the site. If at all possible, send those two pieces of data to the HTLN Fire ecologist.

10-hr fuel moisture stick sampling

There is a special scale to weigh the sticks prior to a fire. The fire ecologist or fire monitor on the fire will be responsible for collecting the measurement. The value in percent will be reported to the burn boss and recorded for the fire report. At the time of each collection weather observations will be taken. Record dry and wet bulb temperatures, dew point, relative humidity, wind speed and direction, and cloud cover. Precipitation can be measured from the park weather station or rain gauge placed at the sampling site.

10-hr fuel moisture stick post-fire

The sticks may remain in place after the fire especially if you would like to continue to monitor fuel moisture or you have additional burns planned. If keeping the sticks out throughout the growing season, you may need to periodically clip the grass beneath the sticks to keep plants from growing up through them. It is advised to deploy a new set of sticks each year. The fire ecologist will provide them to parks.

Woodland fuel moisture

Samples will be collected prior to a prescribed fire. Samples will not be collected if there is freestanding water on the fuels. If it has recently rained, sampling will occur after the surface moisture has dried. In order to correlate with NFDRS, fuels should be collected as close to 1400 hrs as possible and fuel sampling location is situated on a predominantly south aspect. Three to four samples of each fuel type present will be collected and their fuel moistures averaged by site. Collected materials will be placed in airtight containers and weighed as soon as possible to accurately determine material weights. The samples will be dried in a convection oven at 100° C for 24 to 48 hours (depending on size), re-weighed, and fuel moistures calculated. The formula used is (wet weight – dry weight)/(dry weight).

Samples will be taken by two methods, 1. collection and 2. in situ meter measurement.

1. Collection. Fine fuels that are critical to the spread of fire (leaf litter and 1-hr woody fuels, 10-hr, and 1-hr live fuels). These fuel types will be collected in separate airtight containers. Live fuels such as eastern redcedar (*Juniperus virginiana*) leaves may also be collected in this manner if available.

Live fuels: Samples of eastern redcedar may be taken from within the plot or near the plot. Other live fuels may not be available depending upon season. Using a shears, cut portions of fuels to fill the tin. When collecting live fuels, avoid stems and reproductive parts. Collect leaves from multiple parts on the tree, at about eye level.

Dead fuels: Dead fuels consist of litter and duff. We will focus on litter as duff can be difficult to distinguish from litter or soil. Litter is the top layer of the forest floor composed of loose debris (largely recently fallen needles and leaves), little altered in structure by decomposition. Both brown and slightly gray needles are acceptable but highly weathered litter should be avoided. Care should be taken to avoid collecting any live material in a litter sample. 10-hr fuels can be collected in separate tins.

To locate litter samples: Locate sample by standing on one of the 20 m sides of the site, facing into the site. Begin walking towards the opposite end of the site and randomly toss a 0.01 m^2 hoop. The sample must be at least 4 m from the 50 m transect lines to avoid disturbing the vegetation monitoring locations. Collect litter within the hoop and other fuel types as close to the hoop as possible to fill the container, see below. Toss subsequent hoops in the same manner but beginning from the point of the first sample location.

2. In situ meter measurement. Larger woody fuels in the 100-hr and 1000-hr time lag classes will be measured using a GE Protimeter, mini C BLD2001, http://www.ge-mcs.com/en/moisture-and-humidity/moisture-meters/mini.html. These fuels represent a large portion of the fuel loading and will have the longest residual burning time. Fuels in these lag classes may not be abundant and so random location of samples will not necessarily be possible.

   The meter measures moisture of 6-30% in wood to 1%. Calibration can be checked by holding the electrode needles across the exposed wires of the Protimeter “Calcheck” device. Correct calibration will register a value of 17-19%. The meter readings can be adjusted for various species, however, common tree species we encounter do not need additional calibration. The meter was configured at 20 °C, so for every 5°C above this subtract 0.5% from the value shown on the meter. Likewise, add 0.5 % for every 5°C above 20 °C. Use the following procedure for 100 and 1000 hr fuels.

   - Remove the cap of the meter and turn it on.
   - Insert the needles into the wood until they are as deep as possible.
   - Read the value indicated by the meter. Take measurements from multiple fuels of that lag class rather than multiple readings from the same piece of fuel, if at all possible. If the reading is 30, record 30+ on the data sheet as the meter can only read to a maximum of 30%.
   - After use, replace the cap and switch the meter off by pressing and holding the ON button.

Grassland fuel moisture

Samples will be collected prior to a prescribed fire. Four samples will be collected and their fuel moistures averaged by site. A sample consists of all potential fuel within a randomly located hoop (i.e., live and dead standing plants as well as litter; take care with duff). As in woodland fuel moisture, samples will be weighed as soon as possible after collection and put into a convection oven at 100° C for 24 to 48 hours until the sample reaches a constant weight, re-weighed, and fuel moistures calculated. The formula used is (wet weight – dry weight)/(dry weight).

- Locate sample by standing on one of the 20-m sides of the site, facing into the site. Begin walking towards the opposite end of the site and randomly toss a 0.01-m^2 hoop. The sample must be at least 4 m from the 50-m transect lines to avoid disturbing the vegetation monitoring locations. Toss subsequent hoops in the same manner but beginning from the point of the first sample location.

- At each sample location, clip vegetation to within 2.5 cm of the soil or grass crown. Collect enough material to fill the tin.

- Put material into numbered, pre-weighed tin and record tin number.

Woodland Fuel Moisture Data Sheet

Park: ________   Site code: ___________________
Date(DDmonthYYYY): _________   Observer(s): _________________

Fuel type	**Tin #**	**Wet weight**	**Tare weight**	**Dry –tare (FFI: Dry)**	**Dry + tare (FFI: UV1)**
Live ___________					
Live ___________					
Live ___________					
Live ___________					

Litter___________					
Litter___________					
Litter___________					
Litter___________					

1-hr woody					
1-hr woody					
1-hr woody					
1-hr woody					

10-hr woody					
10-hr woody					
10-hr woody					
10-hr woody					

100-hr woody	**Protimeter (%)**
100-hr woody	
100-hr woody	
100-hr woody	
100-hr woody	

1000-hr woody	**Protimeter (%)**
1000-hr woody	
1000-hr woody	
1000-hr woody	
1000-hr woody	

10-hr fuel moisture stick ________%

Entered by: _________   Date entered: ____________   Checked by: _____________

Grassland Fuel Moisture Datasheet

Park: ________________ Date: ______________

Burn unit: _________________ Recorders: _________________

Site#	Sample	Litter/Grass (L/G)	Tin#	Tare Weight	Dry—Tare (FFI: Dry)	Dry Weight (FFI: UV1)	Notes
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
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	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						
	1						
	2						
	3						

Entered by: __________ Date entered: _____________ Checked by: ______________

Fire Ecology Monitoring Protocol
For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 6 –Downed Woody Fuel Load

Version 1.00 (02/01/2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP explains the use of standard woodland fuel load measurements modified for the HTLN sample site configuration. Note: Downed woody fuel lines are also called Brown's lines.

I. Equipment list

- Go/No Go gauge
- 50 m tapes
- 50 ft tapes
- Chaining pins
- Plastic clear ruler (10 scale)
- Graduated trowel (10 scale)
- Flagging
- Pin flags
- Compass
- Clinometer
- GPS
- Metal detector
- Datasheets
- Maps
- Pencils
- Clip board
- Camera
- Spare rebar
- Spare yellow caps
- Mallet

II. Procedures

Transects are 50 ft long and their origin is from each of the four corners of the sample site (Figure 1). The field data sheet is two-sided, be sure to copy the definitions onto side 2.

1. Lay out measuring tapes for the fuels lines at the prescribed azimuths.

2. Place a flag at each end of the fuels lines. Record event information on a dry erased board. One person will hold the board for the picture while the other photographs each transect line.

3. Measure the fuel loads. 1- and 10-hour fuels are tallied from 0 to 6 ft, 100-hour fuels are tallied from 0 to 12 ft, and 1000-hour fuels are tallied from 0 to 50 ft. A go-no-go gauge (Figure 2) is used to separate particles into lag size classes. Intercepts (crossing the plane

of the transect line) are counted along the transect plane up to 6 ft from the ground. Cones, bark, needles, leaves, and stems and branches attached to live or standing shrubs or trees are *not* tallied.

4. Litter and duff depth measurements are visually estimated along each fuels transect at 1, 5, 10, 15, 20, 25, 30, 35, 40, and 45 ft using a clear plastic ruler or graduated trowel. Carefully insert the measuring tool to find the depth of the litter, then the duff. Avoid disturbing the litter and thus altering the measurement.

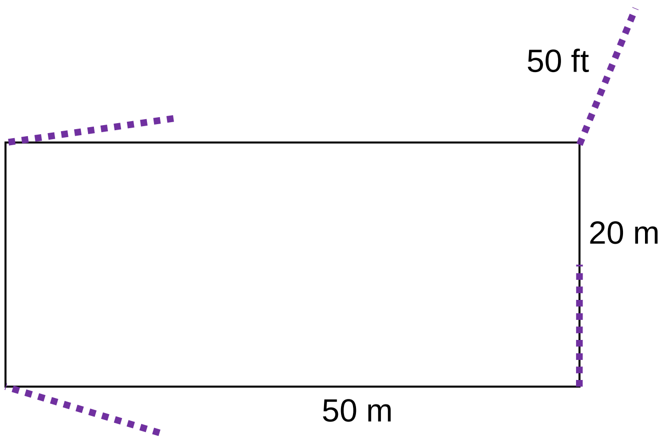

Figure 1. Woodland monitoring sites are 50 m X 20 m with 50 ft transects for fuel load monitoring emanating from each corner in randomly determined directions (purple dotted lines).

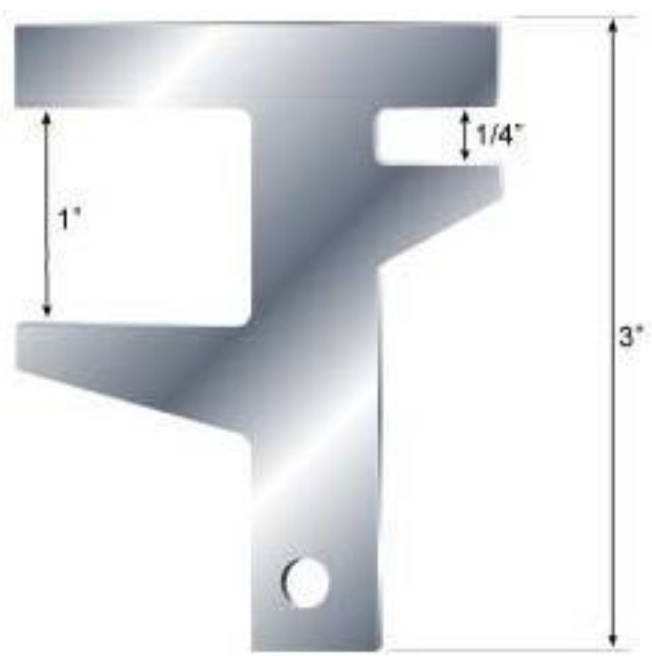

Figure 2. Go-no-go gauge.

FMH-19 Park/Unit 4 Character Alpha Code: ____________

Forest Plot Fuels Inventory Data Sheet

(Downed Woody Fuel Load Data Sheet)

Page____ of____

Site ID: ____________ Date:_____/_____/_______

Burn Unit: ____________ Recorders: ____________

Burn Status: Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00 PRE ________ Post -01yr -02yr -05yr -10yr -20yr Other: -yr -mo

Transect lengths (ft): 0-0.25 6 0.25-1: 6 1-3: 12 3+s: 50 3+r: 50

	# Intercepts			Diameter (in)		Litter and Duff Depths (in)					
	0–.25" (1-hr)	.25–1" (10-hr)	1–3" (100-hr)	3+s (1,000-hr)	3+r (1,000-hr)		L	D		L	D
Transect 1 AS Dir._____° Slope____%						1			25		
						5			30		
						10			35		
						15			40		
						20			45		
Transect 2 AF Dir._____° Slope____%						1			25		
						5			30		
						10			35		
						15			40		
						20			45		
Transect 3 BS Dir._____° Slope____%						1			25		
						5			30		
						10			35		
						15			40		
						20			45		
Transect 4 BF Dir._____° Slope____%						1			25		
						5			30		
						10			35		
						15			40		
						20			45		

Date Entered: ___/___/___ Initals ____________

Definitions

Litter — Includes freshly fallen leaves, needles, bark, flakes, fruits (e.g., acorns, cones), cone scales, dead matted grass, and a variety of miscellaneous vegetative parts. Plants in the litter layer could be identified to genus or species. Does not include twigs and larger stems.

Duff — The fermentation and humus layers; does not include the freshly cast material in the litter layer, nor in the post-burn environment, ash. The top of the duff is where needles, leaves, fruits and other castoff vegetative material have noticeably begun to decompose. Individual particles usually are bound by fungal mycelia. and are no longer identifiable to genus or species. The bottom of the duff is mineral soil.

Downed Woody Material — Dead twigs, branches, stems and boles of trees and shrubs that have fallen and lie on or above the ground.

Obstructions Encountered Along Fuel Transects — If the fuel transect azimuth goes directly through a rock or stump, in most cases you can run the tape up and over it. If the obstruction is a tree, go around it and pick up the correct azimuth on the other side. Be sure to note on the data sheet on which side of the bole the tape deviated so that it will be strung the same way in the future.

Litter and Duff Measurement Rules

- If the transect is longer than 50 ft, do not take additional litter and duff measurements.
- Do not take measurements at the stake (0 point); it is an unnatural structure that traps materials.
- At each sampling point, gently insert a trowel or knife into the ground, until you hit mineral soil, then carefully pull it away exposing the litter/duff profile. Locate the boundary between the litter and duff layers. Vertically measure the litter and duff to the nearest tenth of an inch.
- Refill holes created by this monitoring technique. Avoid remeasuring the soil disturbed by monitoring itself.
- Do not include twigs and larger stems in litter depth measurements.
- Occasionally moss, a tree trunk, stump, log, or large rock will occur at a litter or duff depth data collection point. If moss is present, measure the duff from the base of the green portion of the moss. If a tree, stump or large rock is on the point, record the litter or duff depth as zero, even if there is litter or duff on top of the stump or rock.
- If a log is in the middle of the litter or duff measuring point, move the data collection point one foot over to the right, perpendicular to the sampling plane.

Tally Rules for Downed Woody Material

- Measure woody material first to avoid disturbing it and biasing your estimates.
- Do not count dead woody stems and branches still attached to standing shrubs and trees.
- Do not count twigs and branches when the intersection between the central axis of the particle and the sampling plane lies in the duff.
- If the sampling plane intersects the end of a piece, tally only if the central axis is crossed.
- Do not tally any particle having a central axis that coincides perfectly with the sampling plane.
- If the sampling plane intersects a curved piece more than once, tally each intersection.
- Tally uprooted stumps and roots not encased in dirt. Do not tally undisturbed stumps.
- For rotten logs that have fallen apart, visually construct a cylinder containing the rotten material and estimate its diameter.
- When stumps, logs, and trees occur at the point of measurement, offset 1 ft (0.3 m) perpendicular to the right side of the sampling plane.
- Measure through rotten logs whose central axis is in the duff layer.

Fire Ecology Monitoring Protocol
For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 7 –Grassland Fuel Loads

Version 1.00 (02/01/2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

There are a variety of direct and indirect ways to measure fuel loads (biomass) in grasslands. We have chosen to measure it directly (via clipping). An optional photographic technique may be used at TAPR for special projects only. The photographic technique cannot be used where vegetation is dense, shrubby, and ungrazed vegetation structure similar to the grassland areas at WICR. This indirect method is a photographic technique that relies on a calibration curved developed in 2009. In 2010, TAPR management staff indicated that they preferred the clipping technique as the standard method.

I. Equipment List

50 m tapes
Chaining pins
Flagging
Pin flags
Compass
Metal detector
Datasheets
Maps
Pencils
Clip board
Camera
Shears
Grass hooks
Paper bags
0.10 m hoop

II. Procedures

Clipping

Collect at four samples from each site. Samples are collected using a 0.1 m^2 circular frame and placed in a paper bag.

1. Label paper bags prior to beginning each sample. Sample bags should be labeled with the following information: *Park code_site number, date (ddmonthyyyy), sample location*.

2. For pre-burn sampling, stand at each of the four corners of the site facing into the site. Toss the sampling frame over your right shoulder to locate the sample. The sample locations must be at least 4 m (4 large steps) from each corner of the site to avoid confounding vegetation monitoring. If the substrate within the hoop is > 60% rock, retoss the hoop. If the second toss is also > 60% rock, do not collect the sample. Note on datasheet.

3. Clip vegetation, including standing dead plants, to within 2.5 cm of the ground or grass crown and place in a labeled bag. Avoid clipping threatened or endangered species.

4. Also collect litter, but avoid duff. Although both elements contribute to fuel load, duff can be difficult to distinguish from soil. Add the litter to the bag of clippings.

5. Roll the top of the bag to close it. Samples should be processed as soon as possible post-collection.

6. Samples are oven-dried for 24-48 hours at 100° C and reweighed. The dry weight is then used to calculate total fuel load. The weight of the bag must be subtracted from the sample weight for an accurate measurement. If the same type of bag is used for several samples, dry and weigh 10 similar bags, then use the average dry bag weight as the container weight in all calculations.

7. Weights are entered into the FFI database. *NOTE: the dry weight column is the dry weight of the plant matter minus the tare weight. Put the dry weight plus tare into UV1.

8. Convert fuel loads to English for fire reports:

   A. Scale up to hectare:
   Description: kg/ha **= (**dry sample weight (g) / area of sample 0.1 m^2) * (10,000 m^2 / 1 ha) * (1 kg / 1000 g)
   Simplified formula: kg/ha = dry weight*100

   B. Convert to English units
   Description: tons / acre = (kg/ha from step one * 0.001102 ton/ 1 kg) * (1 ha / 2.47 acre)
   Simplified formula: tons / acre = (Value from step one* 0.0011) / 2.47
   Convert directly to English: tons / acre = dry weight (g) * 0.0446

Grassland Fuel Load Datasheet

Park: ________________ Date: ______________

Burn unit: _________________ Recorders: _________________

Site	Transect	Sample location	Type (Item Code)	Status (e.g. live/dead)	Tare Weight	Green Weight	Dry—Tare (FFI: Dry)	Dry Weight (FFI: UV1)	Comments

Entered by: ____________ Date entered: _____________ Checked by: ______________

Photoboard method (TAPR only) optional for special projects only

Equipment

Retractable washline
Chaining pins
White board
Monopod
Datasheets
Maps
Pencils
Clip board
Camera

1. Sample points are the breeding bird grid. Navigate to point (Points were randomly generated within reference frame in GIS.). Erect photoboard so that the board faces perpendicular to the sun. Facing the sun causes shadows and facing away causes the board to look dark. Avoid sampling when the sun is low in the sky.

   **Point rejection criteria: vegetation between the board and camera must be relatively similar. If not, move the point, or choose one of the extra points.

2. Align the board perpendicular to the sun to minimize shadows throughout the day. To avoid distortion, the board holder must adjust the board to be both level and plumb using a level. Make sure the camera is vertical using a level. Adjustments to the horizontal axis of the board can be made in Photoshop.

3. Take photograph at 4 m away from the board and 1 m high. Record photograph number and/or order on datasheet as well as any pertinent notes.

<u>Photography procedure</u>

Take photos at 4 m from the photoboard. Remove measurement rope from the field of view for each shot. The camera should be mounted on a tripod or monopod at 1 m high. Place the camera centered with the photoboard to avoid distortion. Use manual focus, color photo options. We found that the landscape mode worked best. Focus on the photoboard (not intermediate vegetation) as best as possible. The original protocol said to zoom into the photoboard to fill the frame as much as possible with the photoboard, but we found it better to avoid zooming in so that the depth of field for each picture was exactly the same. Make sure to include the bottom of the photoboard in the photograph.

<u>Lab and office procedures</u>

4. Photographs were processed with Adobe Photoshop CS4. Putting a grid over the picture can aid straightening and measuring.
   A. Digitally straighten image.

   B. Measure image to find bottom of the photoboard.

   C. Crop image to just the photoboard. If image does not include the bottom of the photoboard, discard the sample.

D. Display histogram. Adjust threshold (use default if possible). Be consistent in deciding what threshold is best. Use the graph of image intensity as a guide.

E. On histogram, click the “!” and record the percent from the values below the histogram. This is the % of black in the picture (Digital Obstruction) which should be equivalent to biomass.

F. Use calibration curve to calculate biomass (< 1 yr since burn $y = 1.28x - 6.03$, 1 yr since burn $y = 2.33x - 22.09$, and 2 yr since burn $y = 1.75x - 6.36$).

Photoboard Datasheet

Date : ______________ Photographer: ___________ Observers: ______________
Relevant weather notes: ____

Patch/ pasture	Site	Sample	Time (24hr)	Picture #	% bare	% litter	Notes

Entered by: __________ Date entered: _____________ Checked by: ______________

Fire Ecology Monitoring Protocol
For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 8 – Soil Moisture

Version 1.00 (02/01/2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP describes the collection of soil samples within monitoring sites to measure moisture levels. Two methods common for measuring soil moisture are: *gravimetric* which involves the actual collection of soil, and *volumetric* which can be measured with most standard meters. Volumetric is preferred, but in the event that the meter fails, gravimetric sampling could be done and the values converted to volumetric. A meter is preferred for the measurement because it is less invasive. Saturated soil typically is 40-50% volumetric water content (VWC).

Figure 1. ECH2O Check.

We use the Decagon ECH_2O Check meter with EC-5 probe, 2006 Decagon Devices, Inc. Pullman WA 99163 (Figure 1). The EC-5 probe reads 0-100% VWC at an accuracy of ±3% and 0.1% resolution. An operation manual is found at: http://www.decagon.com/assets/Manuals/ECH2O-Check-Operations-Guide. To operate the meter, push the ON button (Figure 1). Choose probe type E5 for the EC-5 sensor. Use the Mode select button to choose PCT for percent VWC as the desired data type. Attach the sensor, insert the probe, then push the ON button for an instant reading. Use the factory calibration settings; a calibration manual for the probe can be downloaded from http://www.decagon.com/assets/Uploads/13392-03-AN-Calibration-Equations-for-the-ECH2O-EC-5-ECH2o-TE-and-5TE-Sensors.pdf.

I. Equipment list

- 50 m tapes
- 0.01 m^2 hoops
- Chaining pins
- Flags
- Compass
- GPS
- Metal detector
- Clippers
- Datasheets
- Maps
- Pencils
- Clip board
- Camera
- Meter (Decagon ECH_2O Ch_eck meter with EC-5 probe)

II. Procedures

Volumetric (preferred)

1. Locate the sample location as in grassland fuel moisture sampling. Locate sample by standing on one of the 20 m sides of the site, facing into the site. Begin walking towards the opposite end of the site and randomly toss a 0.01 m^2 hoop. The sample must be at least 4 m from the 50 m transect lines to avoid disturbing the vegetation monitoring locations. Toss subsequent hoops in the same manner but beginning from the point of the first sample location. After collecting the fuel moisture sample, proceed with soil moisture collection as follows:

2. Brush away any remaining herbaceous material or litter and duff after fuel moisture collection. It is best to take soil samples in the interstitial spaces between grass clumps.

3. Turn meter on, check settings, attach probe, and gently push probe into the soil. At least half of probe should be inserted into the soil. It is best if the whole probe is inserted. If the probe hits a rock or something hard, reinsert the probe within a couple inches of the first attempt. If that fails, relocate the sample as in step 1.

4. Push the ON button to trigger a reading. Record the PCT value on the meter. Locate next sample as in step 1.

Gravimetric

In the event that the electronic meter fails, gravimetric sampling may be done. Gravimetric sampling requires removing soil from the park for analysis. Saturated soil may read ≥100% gravimetric water content in a saturated condition. If using gravimetric measurements confirm compliance with each park. *At HEHO contact the park historian prior to sampling with the gravimetric technique. Do not collect gravimetric soil samples at EFMO or PIPE. PIPE has installed a permanent monitoring station which reports soil moisture.*

Equipment

- 50 m tapes
- 0.01 m^2 hoops
- Chaining pins
- Flags
- Compass
- GPS
- Metal detector
- Tins (3-5 per site)
- Trowels
- Clippers
- Grass hooks
- Datasheets
- Maps
- Pencils
- Clip board
- Camera

1. Follow step 1 and 2 in volumetric procedure above.

2. Brush away any remaining herbaceous material or litter and duff after fuel moisture collection and collect soil from the upper 2-3 cm using a trowel. It is best to take soil samples in the interstitial spaces between grass clumps.

3. Remove rocks and pebbles as you put soil in the tin. Avoid collecting roots if possible. Collect enough soil to completely fill the tin, but collecting from within the top 2 inches of soil.

4. Samples should be weighed as soon as possible after collection, then oven-dried for 24-48 hours at 105° C and re-weighed. Samples should reach a constant weight before the final weight is taken. Use a pair of gloves as the tins will be hot after being in the oven. Dry weight can then be used to calculate moisture content.

5. Percent soil moisture = (sample wet weight – sample dry weight) / sample dry weight * 100).]

Soil Moisture Data Sheet

Park: ________________ Date (DDmonthYYY): ________________

Burn unit: ________________ Recorders: ______________________________

	Site#	Method Meter (M)/ Collection (C)	% (M)	Tin# (C)	Wet Weight (C)	Tare Weight (C)	Dry Weight (C)	Comment
SOIL 1								
SOIL 2								
SOIL 3								
SOIL 4								
SOIL 1								
SOIL 2								
SOIL 3								
SOIL 4								
SOIL 1								
SOIL 2								
SOIL 3								
SOIL 4								
SOIL 1								
SOIL 2								
SOIL 3								
SOIL 4								
SOIL 1								
SOIL 2								
SOIL 3								
SOIL 4								
SOIL 1								
SOIL 2								
SOIL 3								
SOIL 4								
SOIL 1								
SOIL 2								
SOIL 3								
SOIL 4								

Entered by: __________ Date entered: _____________ Checked by: ______________

Fire Ecology Monitoring Protocol
For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 9 –Fire Weather

Version 1.00 (02/01/2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP describes the collection of weather data on burn day. Observations may be reported to the National Weather Service to assist them with increasing forecast accuracy.

I. Equipment list

- Flagging
- Compass
- GPS
- Datasheets
- Maps
- Pencils
- Clipboard
- Camera
- Belt weather kit
- Kestrel
- Fireline Handbook Appendix B (National Wildfire Coordinating Group 2006)

II. Procedures

1. Upon checking in at the fire, ask the burn boss if a spot forecast needs to be requested. If so, refer to the contact information below.

2. Record spot forecast information in the Evaluation form. If serving as the Fire Effects Monitor (FEMO), the burn boss will request that weather be measured pre-fire and at specific intervals throughout the operation. Measuring the weather involves using a sling psychrometer to collect air temperature, wet bulb temperature, and calculating relative humidity (RH). Collect temperature readings in the shade. Remove the psychrometer from the case. Wet the thermometer with a wick on it. Holding the handle, swing the psychrometer in a circular motion for about 1 minute. Read the two temperatures, then swing the instrument for another 20-30 seconds. If the values have stabilized, record them. Use a humidity table to determine the RH and dew point. Check the value with a Kestral® if needed. A Kestrel® or hand held anemometer can be used to measure wind

speed and a compass should be used to determine wind direction. Stand facing the wind to take the wind speed measurement. Remember, winds are named from the direction they come *from*. Record average wind speed in miles per hour along with maximum gust speed. Fine dry fuel moisture (FDFM) can be calculated from these data as well as probability of ignition (PIG).

3. For calculations of FDFM and PIG use Appendix B: Fire behavior (National Wildfire Coordinating Group 2006). Using dry bulb temperature and RH read reference fuel moisture from Table 2, page B-25. Determine dead fuel moisture correction by choosing Table 3 or 4 depending on the time of year. Read the correction value from the table. Add the correction value to the reference fuel moisture from Table 2 for the final FDFM value. For PIG, apply FDFM and the temperature to Table 12. PIG values are often needed at the beginning of a burn and late in the day.

4. Record the data in the datasheet below as well as reporting to the burn boss or over the radio to the fire crews. Additional detailed instructions for measuring the weather are found in the workbook for S290, a class required for the FEMO position.

III. National Weather Service Offices

<u>WICR and GWCA</u>

NOAA's National Weather Service
Springfield, MO Weather Forecast Office
Springfield-Branson Regional Airport
5805 West Highway EE
Springfield, MO 65802-8430
417-863-8028

<u>EFMO and HEHO</u>

NOAA's National Weather Service
La Crosse, WI Weather Forecast Office
N2788 County Road FA
LaCrosse, WI 54601
608-784-7294

<u>HOME</u>

NOAA's National Weather Service
Omaha/Valley, NE Weather Forecast Office
6707 North 288th Street
Valley, NE 68064-9443
402-359-5166

PIPE

NOAA's National Weather Service
Sioux Falls, SD Weather Forecast Office
26 Weather Lane
Sioux Falls, SD 57104-0198
605-330-4247

TAPR

NOAA's National Weather Service
Topeka, KS Weather Forecast Office
1116 NE Strait Avenue
Topeka, KS 66616-1698
785-234-2592

Evaluation of Spot Weather Forecast

Date: _____________

Time: ____________

Prescribed Fire: ________________

NPS Unit: ____________________________

Parameter	Forecasted	Observed
Winds		
Temperature		
Relative Humidity		
Sky/weather		

Discussion

Signed:

HTLN Fire Monitoring Team

WEATHER OBSERVATIONS: Land Unit: ____________ Fire Name: _____________ Observer(s): _____________ Date: ______

Time	***Location***	***Elev.***	***Aspect***	***Weather State****	***Temperature***		***DP***	***RH***	***Wind***		***1-hr TLFM***	***Comments***
					Dry	***Wet***			***Dir.***	***Speed***		

***State of Weather Codes:**
0 = Clear   1 = 10-50% cloud cover   2 = 50-90% cloud cover   3 = 90%+ cloud cover   4 = Foggy
5 = Drizzling   6 = Raining   7 = Snow or Sleet   8 = Showering   9 = Thunderstorms

comments include:
- ppt. amount/duration
- erratic winds

Fire Ecology Monitoring Protocol
For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 10 –Fire Behavior

Version 1.00 (02/01/2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

The objective of monitoring fire characteristics in forest or grassland is to observe safety while simultaneously obtaining representative fire behavior measurements wherever possible. Fire weather and behavior observations (rate of spread, flame length, and flame depth) should be collected in the same vegetation types represented by monitoring sites and in an area where the fire behavior is representative of fire behavior on the sites. Where safe, fire behavior observations can be made near a monitoring plot.

I. Equipment list

Stop watch
Fireline Handbook Appendix B (National Wildfire Coordinating Group 2006)
Flagging
Compass
GPS
Datasheets
Maps
Pencils
Clipboard
Camera

II. Procedures

Rate of Spread

Rate of Spread (ROS) describes the fire progression across a horizontal distance; it is measured as the time it takes the leading edge of the flaming front to travel a given distance. ROS is expressed in chains/hour, but it can also be recorded as meters/second. It is often easier to record the measurement in the field as ft/min *(1 ft/min = 0.9090 ch/hr)*. Make your observations only after the flaming front has reached a steady state and is no longer influenced by adjacent ignitions. Use a stopwatch to measure the time elapsed during spread. The selection of an appropriate marker, used to determine horizontal distance, is dependent on the expected ROS. Pin flags, rebar, trees, large shrubs, rocks, etc. can all be used as markers. Markers should be spaced such that the fire will travel the observed distance in approximately 10 minutes. If the burn is very large and can be seen from a good vantage point, changes in the burn perimeter can be used to calculate area ROS. If smoke is obscuring your view, try using firecrackers.

Flame Length

Flame length is the distance between the flame tip and the midpoint of the flame depth at the base of the flame—generally the ground surface, or the surface of the remaining fuel (see Figure 2). Flame length is described as an average of this measurement as taken at several points. Estimate flame length to the nearest inch if length is less than 1 ft, the nearest half foot if between 1 and 4 ft, the nearest foot if between 4 and 15 ft, and the nearest 5 ft if more than 15 ft long. Flame length can also be measured in meters.

Flame Depth

Flame depth is the width, measured in inches, feet or meters, of the flaming front (see Figure 2). Monitor flame depth if there is a management interest in residence time. Measure the depth of the flaming front by visual estimation.
Note: Where close observations are not possible, use the height (for FL) or depth (for FD) of a known object between the observer and the fire behavior observation interval to estimate average flame length or flame depth.

Fire Intensity

Fire intensity is the rate a fire produces heat. Fireline intensity (kW/m) is a function of heat (cal/g)*fuel load (tones/ha)*rate of spread (m/min). The formula can be simplified to 273*flame height$^{2.17}$ (m). For field use, intensity = 3*(10*flame height)^2 (Chandler et. al. 1983).

III. Fireline Safety

- For the monitoring plots to be representative, they must burn under the same conditions and ignition techniques used in the rest of the prescribed fire block. **Fire monitor safety, however, must always be foremost.**

- For safety, inform all burn personnel at the pre-burn briefing that the unit contains monitoring plots. It is recommended that you provide a brief discussion on the value of these plots, and your role on the burn.

- Inform all ignition personnel that they are to burn as if the plots do not exist. This will help avoid biased data, e.g., running a backing fire through a plot while using head fires on the rest of the unit.

- Throughout the burn, maintain communications with the ignition specialist and/or ignition team.

- If it would be unsafe to stand close to the flame front to observe ROS, you can place timing devices or firecrackers at known intervals, and time the fire as it triggers these devices.

- Where observations are not possible near the monitoring plot, and mechanical techniques such as firecrackers or in-place timers are unavailable, establish alternate fire behavior monitoring areas near the burn perimeter. Keep in mind that these substitute observation intervals must be burned free of side effects caused by the ignition source or pattern.

FIRE BEHAVIOR: Park code____________ Observer______________ Burn unit___________ Date_____________

Time	*Location*	*Spread Direction*	*ROS*	*FL*	*FZD*	*Intensity (kW/m)*	*Fuel Model*	*1-hr TLFM*	*% Shading*	*% Slope*	*Comments*

Spread Direction: **H = heading; B = backing; F = flanking**
Rate of Spread (ROS): **in/sec, ft/min, or ch/hr**
Flame Length: (FL): **nearest inch (0-23 in); 0.5 foot (2-4 ft); 1.0 foot (4-15 ft); 5.0 feet (> 15ft)**
Flame Zone Depth (FZD): **nearest inch (0-23 in); 0.5 foot (2-4 ft); 1.0 foot (> 4 ft)**
Intensity: **$3(10FH)^2$** **Flame height (FH): meters**

comments include:
- unusual fire behavior
- 10-hr TLFM
- photo #
- other

Fire Ecology Monitoring Protocol
For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 11 –Smoke Observation

Version 1.00 (02/01/2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP describes the collection of data related to smoke on burn day.

I. Equipment

- Datasheet
- Pencil
- Compass
- Map
- Radio
- Fire weather forecast

II. Procedures

It is especially important to record the time and location of the observation along with any pertinent information about the smoke column and visibility. A datasheet is included below. Not all information will necessarily be collected at every observation point. The situation will dictate which information is important to collect. For example, if the FEMO is working near a road and smoke is impacting visibility on the road, only information about visibility may be collected at that time. Photos may also be taken as additional documentation of conditions.

Elevation of the smoke column is difficult to estimate. Using the fire weather forecast, you may be able to compare the predicted height of the cloud layer to the height of the smoke column. The elevation can also be recorded in a relative way such as low, medium, and high meaning close to the ground or very high in the sky. Record the direction the smoke column is moving. If there is an inversion layer estimate its height. Again this could be relative. Record the visibility in distance along the fireline. This is an estimate rather than a measured value. Pacing could be used if needed. Roadways are often used as a fireline, but may be adjacent to the burn unit. Record estimates in distance if possible. Relative values such as clear or heavy smoke could also be recorded. In the comments section you may record if the column was highly dispersed, or a cohesive column. Report conditions to burn boss and ground crews as needed. Communicate information to burn boss.

SMOKE OBSERVATIONS: Park code___________ Observer_____________ Burn unit__________ Date____________

Time	*Location*	*Elevation*	*Elevation of Smoke Column (AGL)*	*Smoke Column Direction*	*Approx. height Smoke Inversion Layer*	*Fireline Visibility (ft)*	*Roadway Visibility*	*Photo (Y/N)*	*Comments*

Fire Ecology Monitoring Protocol
For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 12 –Fire Progression

Version 1.00 (02/01/2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP describes the documentation of the events of the fire. Where the ignition occurred, what directions igniters moved and what times they reached check points.

I. Equipment list

- Compass
- Watch
- Maps
- Field notebook
- Ink pen or marker
- Radio communication

II. Procedures

It works well to use the incident action plan (IAP) map provided at briefing to keep notes. On the map record time and location of the test fire, as well as time that ignition officially commenced. (It works best to use a pen or marker because pencil is difficult to see on a color map.) Also record general routes followed by the ignition team and times that they reached identifiable landmarks. Try to denote the ignition techniques used throughout the burn area and approximate direction fire spread.

Using ArcMap, draw the progression of ignition on a map from notes written on IAP, weather, fire behavior, and smoke datasheets. Arrows on the map indicate direction of movement of burn crews around the burn unit. Text bubbles can be used to indicate the time of arrival at a location. A narrative describing the progression of the burn as well as fire behavior, events of the day, and additional pertinent information should accompany the map in the burn report. Ask the burn boss to review the draft map. For example, west crew arrived at point B at 1200 hrs. They held at the point for 30 minutes because fire behavior was too extreme. West crew then continued quickly towards point C arriving at 1240 hrs. The map would have check points labeled as well as the time. For interior ignition, as opposed to perimeter ignition, hatching could be used.

Fire Ecology Monitoring Protocol
For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 13 –Immediate Post-burn Assessment

Version 1.00 (02/01/2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP describes procedures for post-burn fire severity measurements in both woodlands and grasslands. We have tested burn severity rating using the Normalize Burn Ratio (NBR) with Landsat data for the Tallgrass Prairie National Preserve. The results were confounded by grazing patterns and topographic variability. Remote sensing with NBR techniques is not likely to represent severity as we have measured it on the ground, however the technique may be appropriate for woodland burn units of sufficient size. Requests for remote-sensed severity data can be made through www.mtbs.gov. We prefer to measure burn severity using field methods modeled after those described in the Fire Monitoring Handbook (USDA National Park Service 2003).

I. Equipment list

- 50 m tapes
- 50 ft tapes
- Chaining pins
- 0.10 m hoops
- Flags
- Compass
- GPS
- Metal detector
- Datasheets
- Maps
- Pencils
- Clip board
- Camera

II. Procedures

Woodland

1. Woodland sites are generally visited within two to three weeks following prescribed fire. This allows time for impacts to overstory trees to become visible. Ground level severity

can be measured as soon as the burned area is cool enough to enter. Smoldering logs could melt measuring tapes and damage other equipment so you may need to wait a day or two to collect the data. Take post-burn photographs of transects. Place flags at each end of the transect so that the entire transect is identifiable in the picture. A white dry erase board should be labeled with park code_site#, transect position (eg. Line A, start (AS)), date, and burn status. A picture of each transect should be taken with one person holding the dry erase board from the outside of the site. The board should be held close enough to the photographer to read the writing on the board. The board should be held at 1 m from the ground if at all possible. Fill the image with the transect and as much of the site as is feasible (as opposed to including the transect and area to the outside of the site). The image number and description should be recorded in a field notebook so that they can be properly labeled after download. Pre- and post-burn photos should be taken from the same perspective. Image labels include park code_site, date (DDmonthYY), burn status, and transect position (eg., HEHO16Apr09_PREBURN10ASAF). These images are stored at: N:\HTLN\Projects\HtlnMsu\Fire\Documents\Photos and in a park specific folder.

4. Evaluate severity on the vegetation monitoring transects at 3-m intervals, using the same staggering technique as for vegetation monitoring (A line starts at 3 m, B-line starts at 0 m) using datasheet Woodland Plot Burn Severity Data Sheet I. At each sample point, evaluate burn severity to the organic substrate and to above-ground plants in a 0.10-m^2 area (circular hoop). Use the burn severity coding matrix included on the datasheets to determine the severity ratings.Burn severity ratings are determined at the same points on the Brown's lines at 1, 5, 10, 15, 20, 25, 30, 35, 40, and 45 feet as litter and duff are measured (see SOP 6). At each sample point, evaluate burn severity to the organic substrate and to above-ground plants in a 0.10-m^2 area (circular hoop) using Woodland Plot Burn Severity Data Sheet II. If the substrate within the hoop is > 60% rock, record both values as 0.

Grassland

1. Grassland sites are often visited the day after a fire or even the same day as the fire.

2. Severity is assessed on the HTLN long-term monitoring vegetation community sites or virtual sites. Lay out measuring tapes for vegetation transects.

3. Take post-burn photographs of transects using procedures described on page 9.Record post-burn severity conditions on the Grassland and Shrubland Plot Burn Severity Data Sheet. Assess burn severity at 3 m intervals as marked on the datasheet for both transects A and B. At each sample point, evaluate burn severity to the vegetation and substrate in a 0.1 m^2 area (circular hoop) and record the values on the data sheet. Use the burn severity coding matrix included on the datasheet to determine the severity ratings. If the substrate within the hoop is > 60% rock, record both values as 0.

Woodland Plot Burn Severity Data Sheet I.

Site Status: ______________ Burn Unit: ______________ Recorders: ____________________

Vegetation transects

Tape position	Vegetation A	Substrate A	Tape position	Vegetation B	Substrate B
3			0		
6			3		
9			6		
12			9		
15			12		
18			15		
21			18		
24			21		
27			24		
30			27		
33			30		
36			33		
39			36		
42			39		
45			42		
48			45		

Burn Severity Code Definitions

	Vegetation	Substrate
Unburned (5)	not burned	not burned
Scorched (4)	foliage scorched an[d] attached to supporting twigs	litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged
Lightly Burned (3)	foliage and smaller twigs partially to completely consumed; branches mostly intact	litter charred to partially consumed; upper duff layer may be charred but the duff layer is not altered over the entire depth; surface appears black; woody debris is partially burned; logs are scorched or blackened but not charred; rotten wood is scorched to partially burned
Moderately Burned (2)	foliage, twigs, and small stems consumed; some branches still present	litter mostly to entirely consumed, leaving coarse, light colored ash; duff deeply charred, but underlying mineral soil is not visibly altered; woody debris is mostly consumed; logs are deeply charred, burned-out stump holes are common
Heavily Burned (1)	all plant parts consumed, leaving some or no major stems/trunks; any left are deeply charred	litter and duff completely consumed, leaving fine white ash; mineral soil visibly altered, often reddish; sound logs are deeply charred, and rotten logs are completely consumed. This code generally applies to less than 10% of natural or slash burned areas
Not Applicable (0)	none present preburn	inorganic preburn

Entered by: _________ Date entered: ____________ Checked by: _____________

Woodland Plot Burn Severity Data Sheet II.

Site ID: _______________ Park: ______________ Date: ____________

Site Status: ___________ Burn Unit: ____________ Recorders: ___________

Brown's lines

Transect 1 AS	1	5	10	15	20	25	30	35	40	45
Vegetation										
Substrate										

Transect 2 AF	1	5	10	15	20	25	30	35	40	45
Vegetation										
Substrate										

Transect 3 BS	1	5	10	15	20	25	30	35	40	45
Vegetation										
Substrate										

Transect 4 BF	1	5	10	15	20	25	30	35	40	45
Vegetation										
Substrate										

Coding Matrix:

5 – Unburned	4 – Scorched	3 – Lightly Burned	2 – Moderately Burned	1 – Heavily Burned	0 – Not Applicable

Note: See reverse for detailed definitions.

Entered by: _________ Date entered: ___________ Checked by: ____________

Woodland Plot Burn Severity Data Sheet II.

Woodland severity definitions

	Vegetation	Substrate
Unburned (5)	not burned	not burned
Scorched (4)	foliage scorched and attached to supporting twigs	litter partially blackened; duff nearly unchanged; wood/leaf structures unchanged
Lightly Burned (3)	foliage and smaller twigs partially to completely consumed; branches mostly intact	litter charred to partially consumed; upper duff layer may be charred but the duff layer is not altered over the entire depth; surface appears black; woody debris is partially burned; logs are scorched or blackened but not charred; rotten wood is scorched to partially burned
Moderately Burned (2)	foliage, twigs, and small stems consumed; some branches still present	litter mostly to entirely consumed, leaving coarse, light colored ash; duff deeply charred, but underlying mineral soil is not visibly altered; woody debris is mostly consumed; logs are deeply charred, burned-out stump holes are common
Heavily Burned (1)	all plant parts consumed, leaving some or no major stems/trunks; any left are deeply charred	litter and duff completely consumed, leaving fine white ash; mineral soil visibly altered, often reddish; sound logs are deeply charred, and rotten logs are completely consumed. This code generally applies to less than 10% of natural or slash burned areas
Not Applicable (0)	none present preburn	inorganic preburn

Grassland severity datasheet

Site ID: ________________ Park: ________________ Date: ______________

Site Status: _______________ Burn Unit: _______________ Recorders: ____________________

Tape position	Vegetation A	Substrate A	Tape position	Vegetation B	Substrate B
3			0		
6			3		
9			6		
12			9		
15			12		
18			15		
21			18		
24			21		
27			24		
30			27		
33			30		
36			33		
39			36		
42			39		
45			42		
48			45		

Burn Severity Code Definitions

	Vegetation	Substrate
Unburned (5)	not burned	not burned
Scorched (4)	foliage scorched	litter partially blackened; duff nearly unchanged; leaf structures unchanged
Lightly Burned (3)	grasses with approximately two inches of stubble; foliage and smaller twigs of associated species partially to completely consumed; some plant parts may still be standing; bases of plants are not deeply burned and are still recognizable	litter charred to partially consumed, but some plant parts are still discernible; charring may extend slightly into soil surface, but soil is not visibly altered; surface appears black (this soon becomes inconspicuous); burns may be spotty to uniform depending on the grass continuity
Moderately Burned (2)	unburned grass stubble usually less than 2 in. tall, and mostly confined to an outer ring; for other species, foliage completely consumed, plant bases are burned to ground level and obscured in ash immediately after burning; burns tend to be uniform	leaf litter consumed, leaving coarse, light gray or white colored ash immediately after the burn; ash soon disappears leaving bare mineral soil; charring may extend slightly into soil surface
Heavily Burned (1)	no unburned grasses above the root crown; for other species, all plant parts consumed, leaving some or no major stems or trunks, any left are deeply charred; this severity class is uncommon in grasslands	leaf litter completely consumed, leaving a fluffy fine white ash, this soon disappears leaving bare mineral soil; charring extends to a depth of 1 cm into the soil; this severity class is usually limited to situations where heavy fuel load on mesic sites has burned under dry conditions and low wind
Not Applicable (0)	none present preburn	inorganic preburn

Entered by: __________ Date entered: _____________ Checked by: ______________

Fire Ecology Monitoring Protocol
For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 14 –Prescribed Fire Monitoring Report

Version 1.00 (02/01/2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

The prescribed fire monitoring report is documentation of the burn itself, and a summary of data collected. It is distributed among partners participating in the burn.

I. Equipment list

- Documents from briefing
- Filled out datasheets for pre- and post-burn data
- Weather records from the burn
- Maps of burn units and actual burned area
- Report template (NRDR found at http://www.nature.nps.gov/publications/NRPM/NRRNRTR.cfm

II. Procedures

A list of potential elements is below. Develop fire reports in a consistent way through time using past reports as a guide. Incorporate available data from the burn into the NRDR template. Potential elements are listed below. The burn boss can assist with missing pieces of information. Include a map of the area planned to be burned as well as a map of the *actual* areas burned. Also include pre-burn and post-burn contrasting photographs of sample sites. Not all sites need to be represented. Choose photographs from sites to capture the range of variation in vegetation and burn severity. Allow the park and burn boss an opportunity to review the document before finalizing it. Create a pdf and distribute to relevant parties. Also place a copy on the HTLN server in the Fire\Documents\Reports\FireReports folder.

List of fire report elements to consider (USDA National Park Service 2003)

- Fire name
- Resource numbers and type (personnel and equipment)
- Burn objectives
- Ignition type and pattern
- Holding strategy
- Fuel moisture information
- Drought index information

- Fire behavior indices information
- Precipitation information
- Test burn description
- Chronology of ignition, fire behavior, significant events, and smoke movement and dispersal
- Temperature
- Relative humidity
- Accuracy of spot weather forecast
- Initial qualitative assessment of results
- Future monitoring plan for area
- Acres burned
- Additional comments
- Map of area burned
- Fire weather observations
- Fire behavior observations
- Smoke observations
- Weather station data
- Fire severity data and assessments

Fire Ecology Monitoring Protocol
For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 15 –FFI Data Management

Version 1.10 (02/01/2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
1.0	3-8-2010	S. Leis	Update burn severity protocol table.	To reflect increased sampling on vegetation transects.	1.10

This standard operating procedure (SOP) gives step-by-step instructions for managing data from the plant community monitoring project of the Heartland I&M Network (HTLN) as it pertains to fire ecological data. FFI (FEAT/FIREMON Integrated) is the primary software environment for fire ecology data. ESRI ArcGIS 9.x is used for managing spatial data associated with monitoring locations. Plant community data collected by HTLN reside in Access databases which will be periodically converted to FFI. Data products will be available through the HTLN Network office (contact information at the end of this document). QA/QC guidelines in this document are based on recommendations of Rowell *et al.* (2004) and S. Fancy at http://science.nature.nps.gov/im/monitor and citations therein.

I. Fire Effects Database - Metadata

Metadata for the HTLN FFI database was developed using NPS Metadata Tools and Editor Version 1.1 (NPS NR-GIS Program). FGDC compliant metadata format is available from the NPS Data Store (http://science.nature.nps.gov/nrdata/).

II. Fire Effects Database - Background

FFI, FEAT-FIREMON Integrated, was developed in an effort to streamline data storage across agencies. FEAT and FIREMON were developed independently for NPS and the USFS, respectively; however, several other agencies now use the database. Despite differing agencies, much of the data being collected is very similar. By integrating these databases, data can be shared and summarized across geographic and agency boundaries more readily and support can be streamlined.

Terminology

In FFI, the data was organized such that data for each park resides in its own individual database. The park then is the "*administrative unit*". The next level of organization is the *Project Unit*. In most cases, it will be advantageous to keep sample sites in one Project Unit. The fire ecology program often uses *monitoring types* (vegetation community types) as project units, grassland or woodland, for example. The next level of organization is the *macroplot*. The term *macroplot* is akin to HTLN's site or LocationID and is the unit of replication. Macroplots can be reassigned to different project units within the database if needed. Finally, within each macroplot, *sample events,* akin to PeriodID in the Vegetation monitoring database, are created. Each sample event can be assigned a monitoring status relative to a type of disturbance event, for example 2009burnImmediate. Monitoring status assignments are made up of a prefix, descriptor, and suffix where the prefix and suffix refer to time and the descriptor is a type of disturbance or treatment. These can be changed at any time and are customizable. Most data entry will occur in the sample event level. Within each sample event a number of protocols can be assigned. *Protocols* in FFI refer to elements of the sampling design such as surface fuels or trees. A protocol is made up of *methods* such as litter/duff or course woody fuels measurements in the fuels protocol.

The Software Program

FFI is developed on a Microsoft SQL Server Express Framework. It contains three related elements 1. project administration, 2. FFI, and 3. protocol manager. Project management is used to initiate a new database, assign permissions, backup and restore the database among other utilities. FFI is used to develop the design hierarchy enter and edit, and query data. Protocol manager is used to edit existing protocols or create new ones. A note of caution—editing existing protocols should be avoided. If the change being considered is substantial enough, consider creating a new protocol. If the standard protocols are edited, it will be difficult to consolidate the data on the regional or national levels.

III. Procedures

Installation

The most recent version of FFI and the SQL framework can be downloaded from **http://frames.nbii.gov/portal/server.pt?open=512&objID=483&&PageID=2285&mode=2&in_hi_userid=2&cached=true.** It is important to follow the procedures in the Users Guide exactly as they are written. Currently, the fire ecologist's computer serves as the master computer, housing the data itself. All new database development and backups must be done from this machine. Also, the master computer and remote computer must be configured to communicate. This is done through settings on the firewall and SQL server configurations. Supporting documents can be found on the FFI Google Discussion Group accessed through the above FRAMES website as well as in links in the users' guide. Additional configurations were necessary to complete the remote computer connection. The firewall on the master computer must be set to allow an exception for SQL server. To configure the firewall, [Control Panel/security center/Windows firewall] click the exceptions tab. (Instructions can be found at http://msdn.microsoft.com/en-us/library/ms175043.aspx). Mark the available SQL applications as allowed exceptions. The following SQL server applications should be added as exceptions: SQL server surface area configuration, sqlbrowser.exe, and sqlservr.exe. Two ports needed to be added. The first port should be named **SQL Server** and assign port number 1433, select TCP. Name the second port **SQL Server Browser** and number it 1434 select UDP. Lastly, in the firewall exceptions click file and printer sharing.

Remote connections were enabled using the documents recommended in the installation guides and http://support.microsoft.com/default.aspx?scid+kb;EN-US;914277 (How to configure SQL

Server 2005 to allow remote connections). Additionally, instructions found at www.datamasker.com/SSE2005_NetworkCFG.htm, (pay particular attention to the IP address instructions as these were not specified in the Microsoft documentation) and www.datamasker.com/SSE2005_SCM2.htm were followed. The remote computer must also be set to communicate. Specifically, [C:\Program Files\Microsoft SQL Server\MSSQL.1\MSSQL], right click properties and click the security tab. A user named "Everyone" was added and given full control. On the master computer side, the administrator was also given full control.

Data Entry

Click on FFI. Select the instance of INPWICRFIRE07\SQLEXPRESS. Type in user name and password. Do not include any stray spaces after the user name or password as they will be counted as a character. Choose the database you would like to work on. On the lower left panel click DATA ENTRY AND EDIT. Click through the navigation trees to the sample event you would like. Choose the proper protocol and begin data entry. Save data often.

A. Brown's lines.

For entering fuels data use the SURFACE FUELS protocol and additional instructions below:

Transect coding: **AS = 1, AF = 2, BS = 3, BF = 4**

Azimuth and slope: should be labeled on each sheet. If not look back at the same transect for a previous year to find the data.

1. Fine Woody debris method

   Fine woody debris # Transects **= 4**
   1 hr transect length **= 6**
   10 hr **= 6**
   100 hr **= 12**
   Azimuth and slope from datasheet (if missing enter 99 and type a comment in the comment field for follow up.
   Add dots for counts and enter counts
   Choose Red Oak fuels constant

   Save

2. Course Woody debris method

   Course woody debris length **= 50**
   Course woody debris # transects **= 4**
   Slope: on datasheet
   Log number: leave blank
   Decay Class: **Rotten = 4, Sound = 3**
   Choose red oak fuels constant

   Save

3. Litter/duff method

   Duff Litter # Transects **= 4**
   Sample location: ft for each measurement from datasheet
   Fuel bed: leave blank
   Choose Red Oak fuels constant

   Save

4. Open new sample event to edit and repeat steps above.

Fuels constants used for HTLN fuels data calculations (red oak (*Quercus rubra*) constants via Dan Swanson, NPS). While the default constants maybe adequate, the red oak constants mostly closely reflect tree composition of woodlands within HTLN parks.

Table 1. Fine woody debris, course woody debris, duff and litter constants for *Quercus rubra*.

Angle Correction			Mean Diameter			Specific Gravity		
NHC1	NHC10	NHC100	QMD1	QMD10	QMD100	SG1	SG10	SG100
1.13	1.13	1.13	0.028	0.100	2.820	0.65	0.58	0.50

Course Woody Constants	Duff/Litter Constants
SG 1-3 = 0.63	Litter = 0.90
SG 4, 5 = 0.30	Duff = 6.0

Fuels constants for red oak were chosen for calculations within the HTLN parks (Table 1). A limited set of tree species where constants have been derived are available. Most tree species available are pine or evergreen type species with lower wood density. Although not always a dominant species, red oak is present in several of the parks and is more similar in nature to the hardwood species we typically encounter.

B. Burn severity protocol

For entering post-burn severity data, use the BURN SEVERITY protocol for data collected on Brown's lines and BURN SEVERITY (METRIC) for data collected on vegetation transects and additional instructions below (Table 2).

Transect coding: Brown's lines: **AS = 1, AF = 2, BS = 3, BF = 4**
Vegetation transects: **A =1, B = 2**

Table 2. Parameters for entering burn severity data by transect type.

Element	Brown's lines	Vegetation transects
# transects	4	2
Length (do not enter units)	50	50
# points/transect	10	16
Plot type	Forest	Forest/Grassland
Point area	155 (in^2)	1000 (cm^2)
Point	1-10	1-17
Tape	1, 5,10,15…	3,6,9,12,15,18,21,24,27,30,33,36,39,42,45,48 or 0,3,6,9,12,15,18,21,24,27,30,33,36,39,42,45

Enter the appropriate vegetation and substrate classes from datasheets.
Save often

C. Grassland Fuel Load protocol

For entering fuel load measured by clipping as in SOP 7, use the BIOMASS PLANTS, METRIC protocol as described below:

5. At the top of the form enter: Num. Transects = 2
Num. Quadrats/Transect = 2
Quadrat Length = 10 (cm)
Quadrat Width = 100 (cm)

6. In the data entry area: Transect: A= 1, B = 2
Quadrat: S (Start) = 1, F (Finish) = 2

7. Item Code: Indicates what kind of materiel is being weighed. Choose a code from the table below (Table 3). ALL will be used most often. If no code exits, one must be entered into the species form as a custom species.

8. Status: describes whether the sample includes live or dead plants enter = N/A

9. Tare weight: the average weight of 10 empty, oven dried collection bags (g).

10. Green weight: weight of materials in collection bag before being dried (g).

11. Dry weight: weight of materiel in bag after being dried (g) minus bag weight.

12. UV1: weight of material in bag after being dried before subtracting bag weight. Save often

Table 3. Item codes for data entry into biomass plants protocol in FFI.

Item Code	Name	Description
LITT	Litter	Includes freshly fallen materials, such as dead matted grass, and a variety of other miscellaneous vegetative parts. The structure of the plants is still easily recognizable.
DUFF	Duff	The fermentation and humus layers; does not include the freshly cast material in the litter layer. The top of the duff is where castoff vegetative material has noticeably begun to decompose. The bottom of the duff is mineral soil.
GRND	Ground	All plant materials lying on the ground; including both litter and duff.
STND	Standing	All standing plant materiel contained within the quadrat area.
ALL	All	All plant materials within the quadrat including litter, duff and standing materials.

Data Verification
Data verification immediately follows data entry and involves checking the accuracy of computerized records against the original source, usually paper field records. While the goal of data entry is to achieve 100% correct entries, this is rarely accomplished. To minimize transcription errors, our policy is to verify 100% of records to their original source by staff familiar with project design and field implementation. Further, 10% of records are reviewed a second time by the Project Manager and the results of that comparison reported with the data. If errors are found in the Project Manager's review, then the entire data set is verified again. Once the computerized data are verified as accurately reflecting the original field data, the paper forms are archived and the electronic version is used for all subsequent data activities.

Procedure
In FFI, on the left panel, choose QUERY. Select the desired protocol and macroplots to verify. Click EXPORT. Save the exported .csv file to a local drive. The exported file can be opened in Microsoft Excel and formatted for printing. The printed data should be checked against the original field sheets for accuracy. Errors should be noted, and then corrected in the FFI database.

Data Validation
See validation methods specified in SOP 10.

IV. Database Administration

Data Maintenance
Data sets are rarely static. They often change through additions, corrections, and improvements made following the archival of a data set. There are three main caveats to this process:

1) Only make changes that improve or update the data while maintaining data integrity.
2) Once archived, document any changes made to the data set.
3) Be prepared to recover from mistakes made during editing.

Any editing of archived data is accomplished jointly by the Project Manager and Data Manager. Every change must be documented in the edit log and accompanied by an explanation that includes pre- and post-edit data descriptions. The reader is referred to Tessler & Gregson (1997) for a complete description of prescribed data editing procedures and an example edit log.

Data Organization
The various databases, reports, GIS coverages, etc. used and generated by the monitoring program create a large number of files and folders to manage. Several experiences from the PC-LTEM reinforce the complicated nature of file management. Although FFI resides on a local computer, backups are made each day that data entry/editing occur. The backups can periodically be transferred to the common network filing system at:
N:\HTLN\Projects\HtlnMsu\Fire\FFI\backups. Backups are automatically given a unique name because the date and time are attached to the name.

Backups and Data Protection

Frequent data backups are essential for protecting data files from corruption. HTLN staff run complete backups of all databases once-a-week and archive monthly (stored for three months), quarterly (stored for one year) and annual backups (archived indefinitely). All backup copies of the data are maintained at three separate physical locations: the Missouri State University campus, the Wilson’s Creek visitor center and the Heartland I&M Building at Wilsons Creek.

V. Data Availability

Data requests can be directed to:

Data Manager
Heartland I&M Network
National Park Service
Wilson’s Creek National Battlefield
Republic MO 65738

Fire Ecology Monitoring Protocol

For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 16 –Data Analysis

Version 1.00 (02/01/2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP describes the types of primary data analyses that could be used to analyze data collected by this protocol. Other analyses are possible, and may be desirable depending upon the development of burn objectives (most of which have not been determined at the time of protocol development). A qualified analyst should be consulted for other data analysis options.

I. Procedures

Objectives

Primary data analyses will focus on specific objectives as outlined in the Fire Monitoring Plans and/or Prescribed Burn Plans for each specific park, burn, or series of burns. Such plans will be continually developed and changed, and thus it is not possible to specify objectives in this protocol. In general, analyses should focus on determining whether the specified objectives have been reached. Most objectives will be stated in terms of a percentage range of reduction in some variable (e.g., reducing fuel load by 50 to 70%) or a goal of obtaining a percentage range of some variable (e.g., reducing shrub cover to 30 to 50%).

Exploratory Analyses

Data should initially be plotted and graphically examined for any potential outliers or errors, or skewness or kurtosis in the distributions. Additionally, one should look for any potentially interesting patterns that might be obscured by taking mean values. Such exploratory data analyses are relatively straightforward, and include graphs such as scatter plots, frequency histograms, and box plots (see Elzinga et al. 2001 for some examples). Such graphs are simple to construct and easy to understand. The *Explore* command in SPSS automatically computes a number of descriptive statistics, and produces a stem and leaf frequency graph and a box plot (and includes other options; Norusis 2008).

Normality should also be evaluated, and if the data reveal evidence of non-normality, the appropriate transformations should be attempted. A $\log_{10}$ transformation will often make a data set more normal, but one should not assume such a transformation will always work. Other transformations are possible (see Kutner et al. 2005). After transformations, the distributions of the transformed data should always be examined. A formal test for normality is available, and other tests can be used to evaluate other statistical assumptions, such as Bartlett's test for the existence of homoscedasticity (Sokal and Rohlf 1995).

Parameter Estimation

Evaluating whether specific burn objectives have been obtained will most often involve parameter estimation. The goal of parameter estimation is to provide the best estimate of the parameter of interest, usually simply by obtaining a mean from the sample units. Examples of objectives likely to be encountered include:

- Was fuel load reduced to desired levels?
- Were woodland trees (e.g., stem density, basal area) reduced to desired levels?
- Were woody plants (e.g., cover) in grasslands reduced to desired levels?
- Were functional groups of plants (e.g., cover) altered to meet goals?
- Were invasive species (e.g., frequency, cover) altered to meet goals?

Confidence Intervals

Some measure of the amount of uncertainty associated with mean estimates should also be provided. This may be in the form of standard deviations, standard errors, or confidence intervals, depending upon the primary information one wishes to convey. Usually confidence intervals will supply the most useful information about the location of a particular parameter. Confidence intervals of 90 or 95% are common. The percentage should depend upon the amount of uncertainty one is willing to accept relative to the need for a precise interval.

Confidence intervals based on the Student's *t* distribution are described in elementary statistics texts. It should be noted that the construction of a confidence interval based on the Student's *t* distribution assumes the data are from a normal distribution. If the data are not normal, the confidence interval will be approximate rather than exact. Non-parametric confidence intervals may also be constructed, although these are usually very wide (Conover 1999). Care must be taken in interpretation of confidence intervals; they are frequently misinterpreted when making comparisons (see Cumming et al. 2004, Belia et al. 2005, Cumming and Finch 2005).

When specific management goals for a given burn or series of burns are available (e.g., reduce fuel load by 50 to 70%), the mean change or state of the variable in question should be determined, and confidence intervals calculated. Comparison of the mean change or state of the variable to the relevant management goals will determine whether such goals were reached. The Fire Monitoring Handbook (USDI National Park Service 2003) contains additional examples and a discussion of this topic.

Control Charts

If long-term threshold values or ranges for variables (as opposed to short-term goals for change) can be specified (e.g. maintaining shrub cover below 50%), a control chart approach may be appropriate. The construction and interpretation of control charts is covered in many texts focusing on quality control in industry (e.g., Beauregard et al. 1992, Gyrna 2001, Montgomery 2001). The application of control charts for ecological purposes is relatively straightforward. The use of control charts in environmental monitoring is discussed in texts by McBean and Rovers (1998) and Manly (2001), although not in as great detail as the texts referenced above focusing on industrial applications. Many different types of control charts could be constructed, depending upon the type of information desired. For example, control charts can be used to evaluate variables or attributes (i.e., count or frequency data), and focus on measures of central tendency or dispersion.

Most traditional control charts utilize control limits that are based on statistical properties of some desired centerline (i.e., mean) value. They assume that observations come from a normal distribution, or that data can be transformed to normality. In industry, control limits are often set at a distance of 3 standard deviations on either side of the centerline (Wetherill and Brown 1991, Beauregard et al. 1992, Montgomery 2001). Thus, assuming a normal distribution centered at the centerline, the control limits would encompass 99.73 % of the distribution. Control limits may be constructed so as to contain any desired proportion of the distribution (i.e., representing [1-α] confidence intervals for any α. In this case, choosing control limits is equivalent to specifying a critical region for testing the hypothesis that a specific observation is statistically different from the proposed centerline value. (It is crucial that the centerline value is representative of the true population parameter.) Control limits could also be based on probabilistic thresholds other than confidence intervals (e.g., McBean and Rovers 1998).

It is not absolutely necessary to use values from a statistical sampling process, however, to construct control charts. It is possible to subjectively choose threshold limits based on management target values or thresholds. It is crucial in this case to realize that probabilities cannot be readily associated with the observations. This application also has a precedent in industry. Such charts, which plot observations without relevance to an underlying distribution, have been termed ‘conformance charts’. Threshold values, which may be subjective, are termed ‘action limits’ (Beauregard et al. 1992). If taking this approach, one should be familiar with the system in question and preferably select values that are defensible based on the data.

Although control charts have potentially wide applicability, each application may be different. A generic process for control chart construction is provided below, although decisions will always have to be made and an analyst familiar with control charts should ideally be consulted.

Steps in constructing a univariate control chart (Figure 1):

1. Determine the parameter of interest. This could be practically any variable measured by this protocol.

2. Plot the values (mean and some value of uncertainty) of the parameter of interest (on the y-axis) against time (on the x-axis).

3. Determine a “center-line” value for this parameter; this could represent a mean of the observations, a target value, or some other value. A center-line is not necessary for conformance charts, as described above.

5. Establish control limits. It is possible that only an upper control limit, or only a lower control limit, or both will be necessary, depending upon the parameter of interest and management goals. Control limits may be based on a probability distribution and thus allow one to make statistical inferences, or they may be based on target levels set by management. Determining appropriate control limits can be complicated, especially if statistical inferences are desired, and an analyst who is familiar with control charts should be consulted.

6. Continue to plot values of the parameter of interest over time as new data become available. If an observation exceeds the control limit(s), this is indicative of the potential need for management action, or a more focused study.

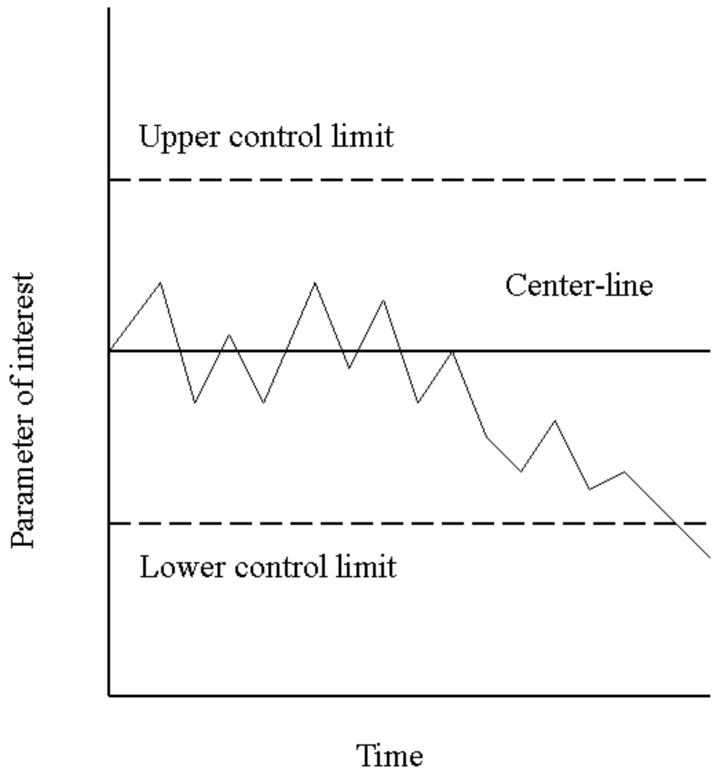

Figure 1. Generic univariate control chart.

Additional Statistical Tests
Additional statistical analyses could be applied, especially at TAPR where fire is used as a management technique in an attempt to alter vegetation structure. The appropriate statistical analyses will depend upon the specific management goals or questions, and the nature of the data. Hypotheses tests could be employed to answer certain questions, although parameter estimation will often be more informative (Morrison 2007). Simple statistical tests could be used to test for differences in variables between years. The paired *t*-test is used with non-proportional variables such as species richness and tree species density and is appropriate for permanent plots. The non-parametric Wilcoxon signed rank test can also be used to test non-proportional variables

for differences between years (Elzinga et al. 2001). The non-parametric McNemar's test can be used with proportional variables such as mean percent cover.

Regression analyses represent an obvious method for analyzing long-term trends. It should be kept in mind, however, that regressions do not test for trend *per se*; they evaluate how well the data fit a specified function. Thus, the first step is to visually examine scatter plots of data for the most appropriate regression function. In general, three types of regression may be useful: linear, curvilinear, and piecewise. See Kutner et al. (2005) for an in-depth treatment of regression models. The most informative approach to a regression analysis is likely to be estimation of regression parameters (e.g., the slope, which is indicative of the rate of change), rather than simple determination of statistical significance (because *P*-values are dependent on sample size).

Analysis of variance (ANOVA) and multiple analysis of variance (MANOVA) could also be used for these data, given the existence of the appropriate design. A repeated measures design would be appropriate given that the same plots are sampled over time.

Environmental Effects

The protocol specifies collection of various environmental data (e.g., total moisture, fuel moisture, weather, etc.). It is anticipated that such data may be useful in understanding why goals were or were not met. This is not expected to be of primary interest and would be done occasionally in a post-hoc manner. A large number of analyses—including both univariate and multivariate approaches—could potentially be applied. It should be kept in mind that such analyses would be correlational rather than confirmatory, and not necessarily include all important factors. A qualified analyst should be consulted, and the specific questions outlined, prior to analyses regarding these variables.

Fire Ecology Monitoring Protocol

For the Heartland Inventory and Monitoring Network

Standard Operating Procedure 17 –Revising the Protocol

Version 1.00 (02/01/2011)

Revision History Log:

Previous Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This Standard Operating Procedure explains how to make and track changes to the Fire Ecology Monitoring Protocol for the Heartland Inventory and Monitoring Network narrative and accompanying SOPs. Observers asked to edit the Protocol Narrative or any one of the SOPs need to follow this outlined procedure to eliminate confusion in how data are collected and analyzed. All observers should be familiar with this SOP to identify and use the most current methodologies.

I. Procedures

1. The Fire Ecology Monitoring Protocol for the Heartland Inventory and Monitoring Network (HTLN) narrative and accompanying SOPs has attempted to incorporate the soundest methodologies for collecting and analyzing fire effects data. However, all protocols regardless of how sound require editing as new and different information becomes available. Required edits should be made in a timely manner and appropriate reviews undertaken.

2. All edits require review for clarity and technical soundness. Small changes or additions to existing methods will be reviewed in-house by HTLN staff. However, if a complete change in methods is sought, an outside review is required. Regional and national staff of the National Park Service with familiarity in plant community research and data analysis will be utilized as reviewers. Also, experts in plant community research and statistical methodologies outside of the Park Service will be utilized in the review process.

3. Document edits and protocol versioning are tracked in the Revision History Log that accompanies the Protocol Narrative and each SOP. Log changes in the Protocol Narrative or SOP being edited only. Version numbers increase incrementally, major changes by whole numbers (i.e. version 1.0, version 2.0, etc.) and minor changes by tenths (e.g. version 1.1, version 1.2, etc). Record the previous version number, date of revision, author of the revision and identify paragraphs and pages where changes are made and the reason for making the changes along with the new version number.

4. Inform the Data Manager about changes to the Protocol Narrative or SOP so the new version number can be incorporated in the Metadata of the project database. The database may have to be edited by the Data Manager to accompany changes in the Protocol Narrative and SOPs.

5. Post new versions on the internet and forward copies to all individuals with a previous version of the affected Protocol Narrative or SOP.

Appendix 1 – Park Maps

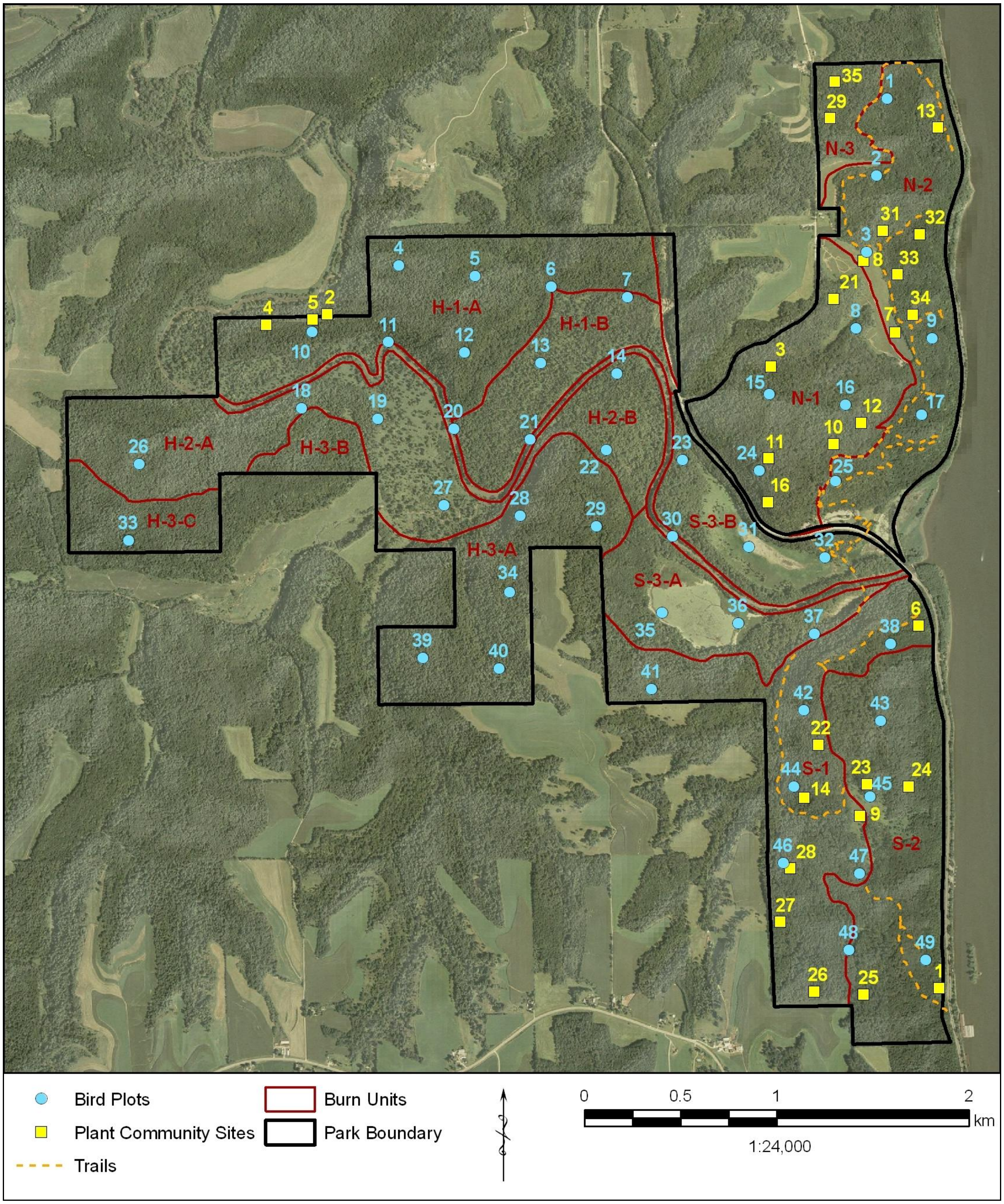

Figure 1. Map of sampling sites at EFMO.

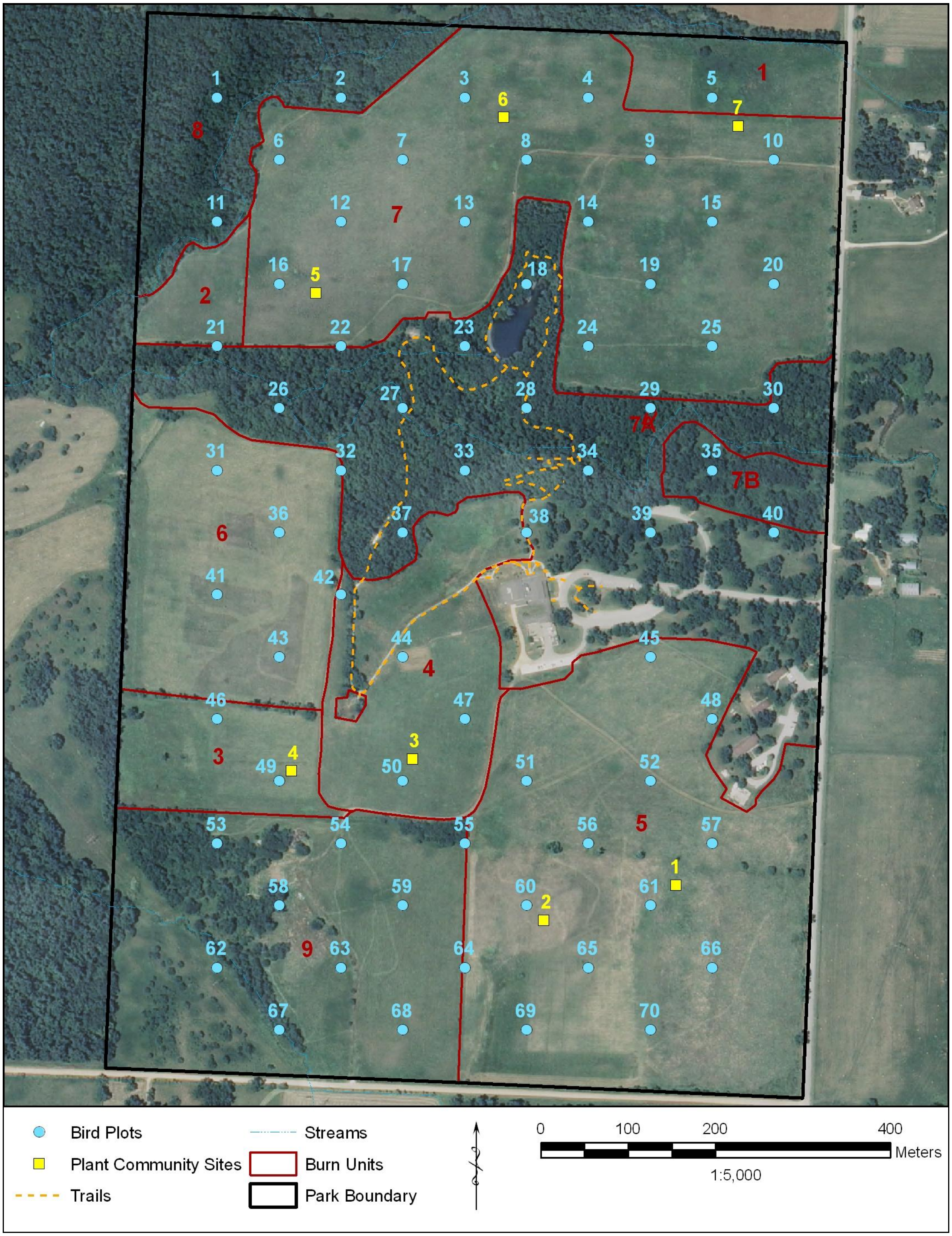

Figure 2. Map of sampling sites at GWCA.

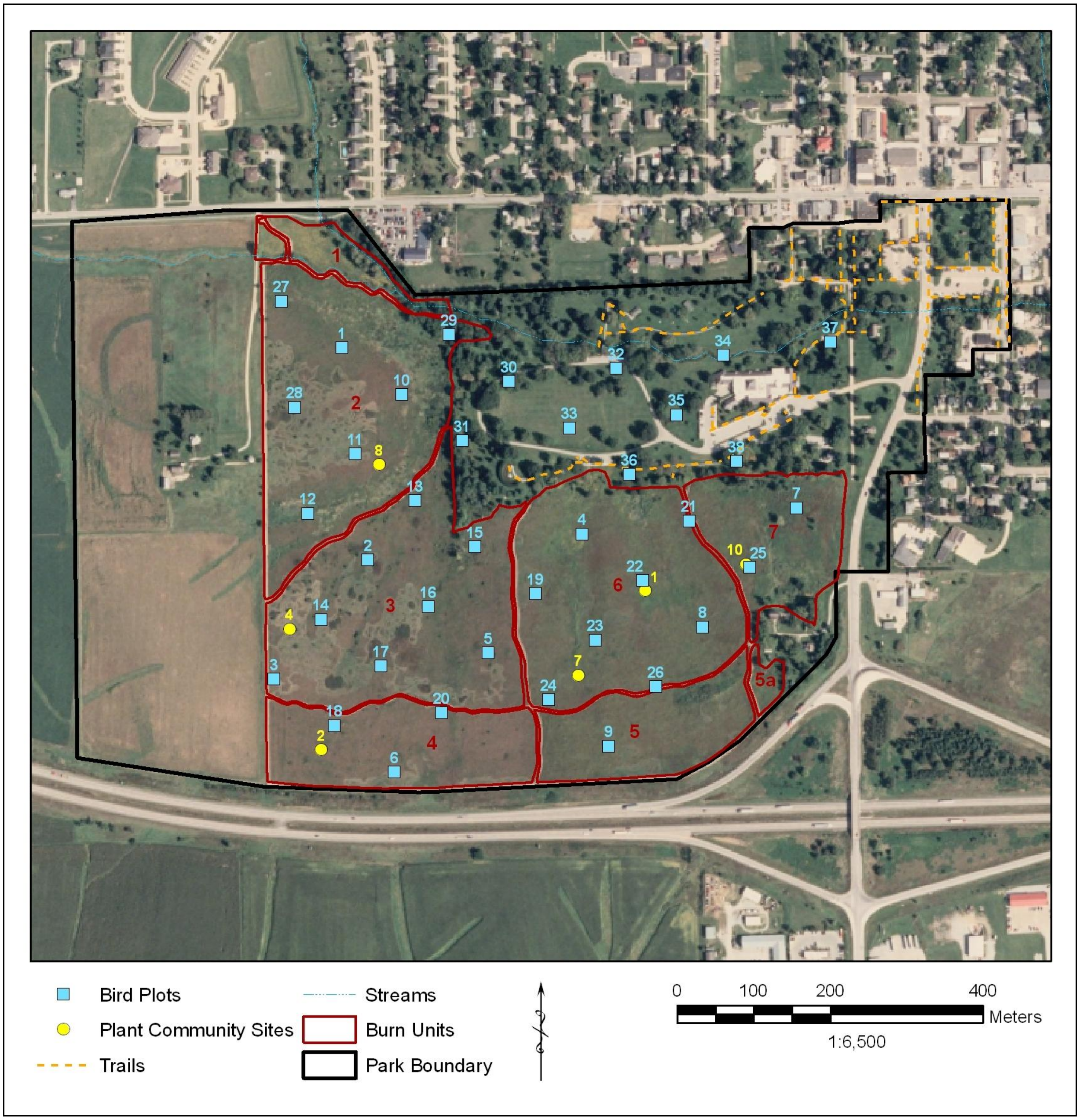

Figure 3. Map of sampling sites at HEHO

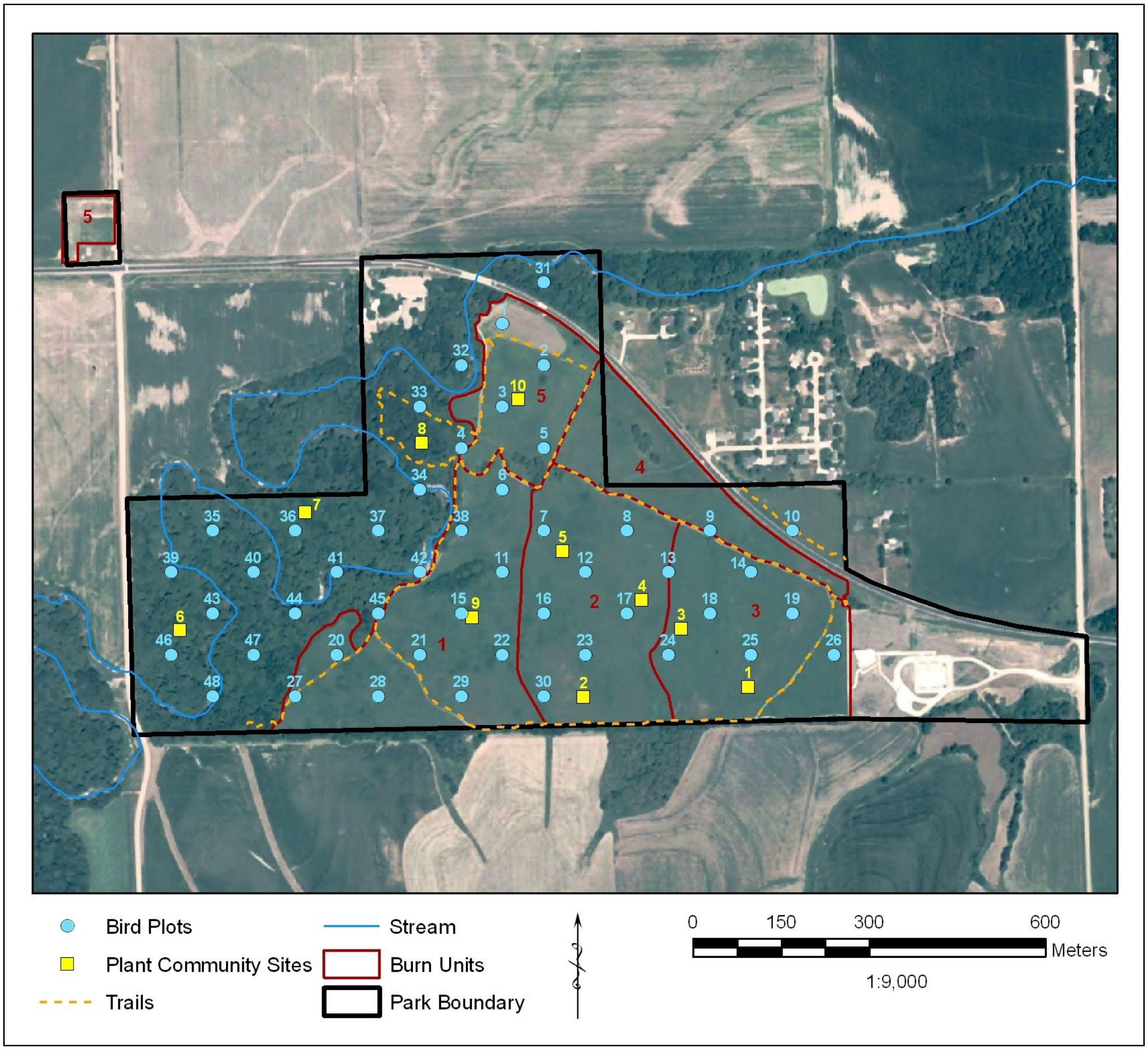

Figure 4. Map of sampling sites at HOME.

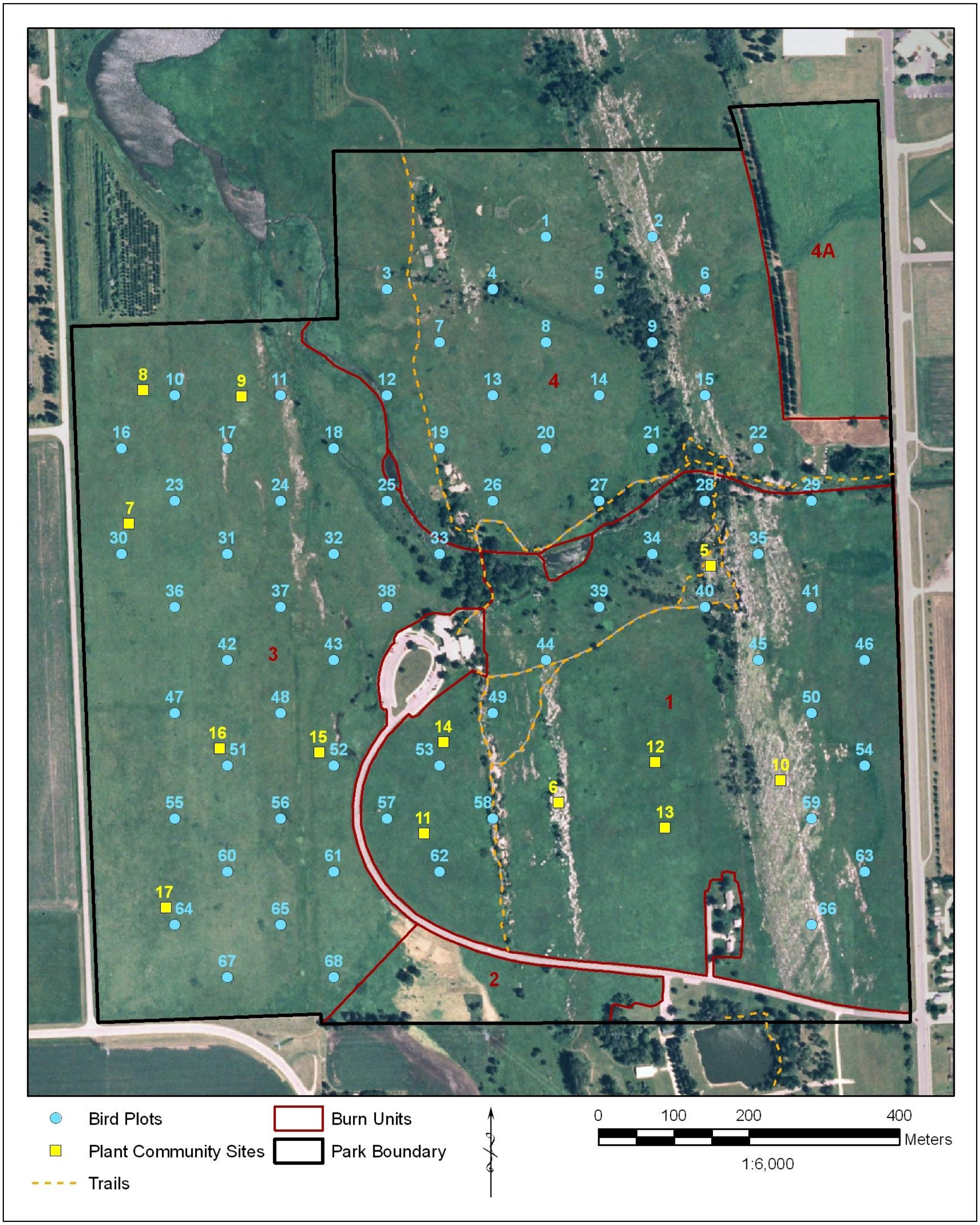

Figure 5. Map of sampling sites at PIPE.

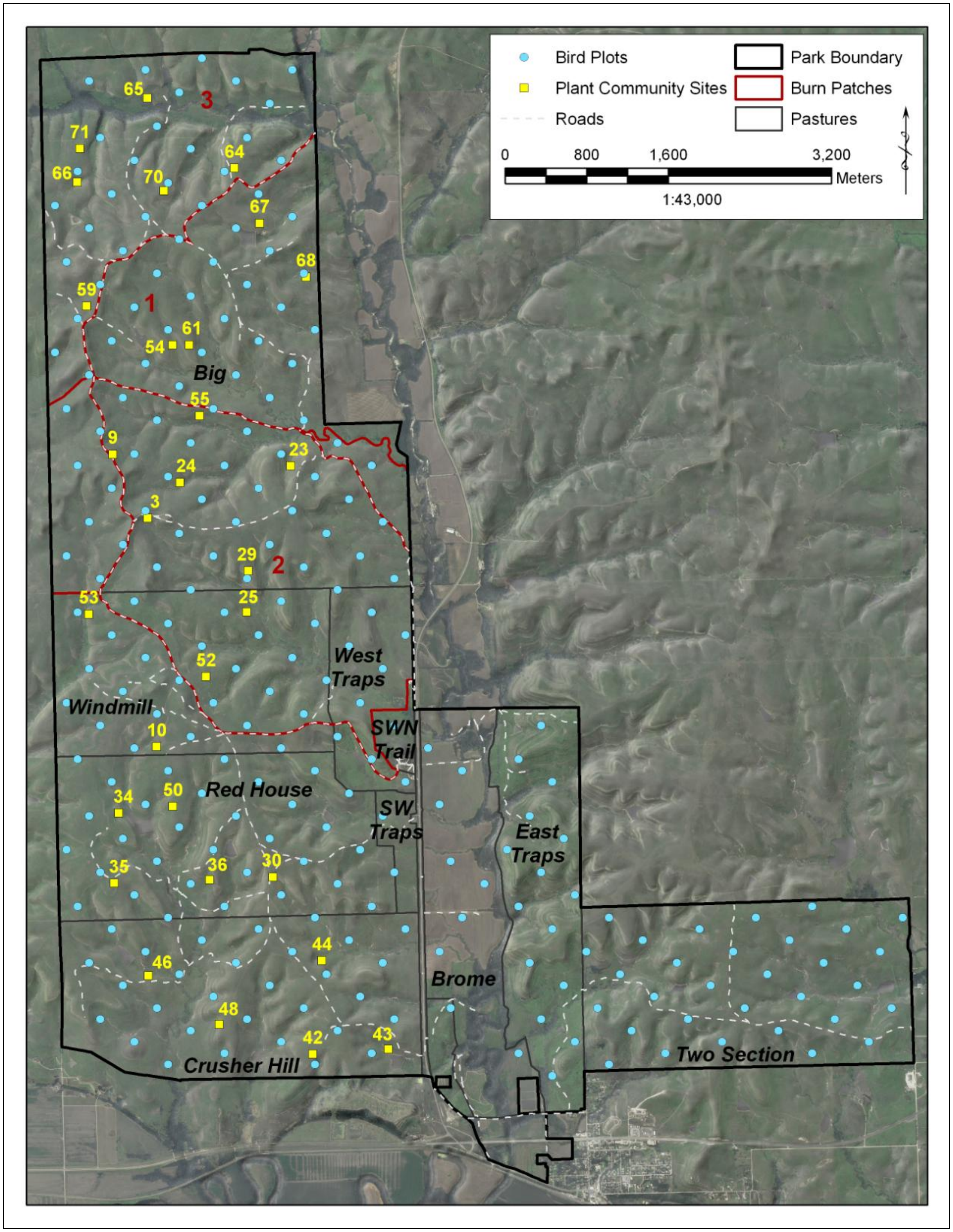

Figure 6. Map of sampling sites at TAPR. Big Pasture is burned in thirds. Each third, or patch, is outlined in red and numbered. Windmill Pasture is usually burned in halves depending on which adjacent pastures are burned. Bird plots will be used to create virtual sites in Windmill, East Traps, Two Section, and Big Pasture.

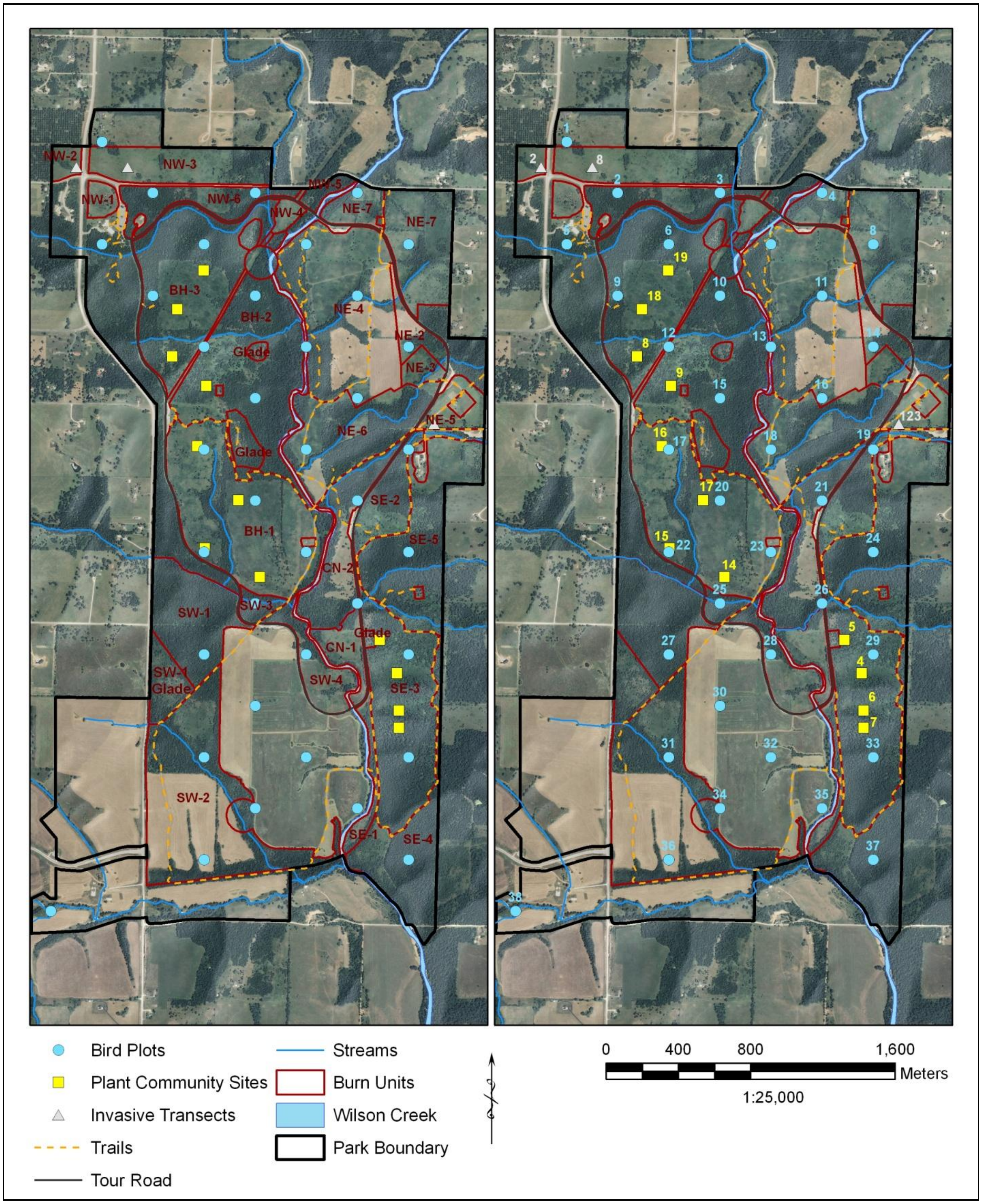

Figure 7. Maps of sampling sites at WICR. Maps are equivalent except for labeling (on left, burn units are labeled, on right, monitoring sites and potential monitoring sites are labeled).

Appendix 2 – Project History

The program grew out of the recognition of an existing need for fire ecology support within several parks in the Midwest region. These parks did not have a dedicated fire ecologist supporting them. As a result, the Midwest Region provided financial support to HTLN to enhance monitoring for TAPR and EFMO in 2001. Despite this effort, seven of the HTLN parks still needed additional monitoring and support to evaluate the efficacy of their prescribed fire goals. An additional step was taken, and a fire ecologist and lead monitor were hired via granted funds from NPS Fire and facilitated by the Great Lakes Cooperative Ecosystems Studies Unit in 2007. The funding was deposited with HTLN partner, Missouri State University. Efforts are underway to create permanently funded positions within the National Park Service.

Administrative history

2001

Began fire effects monitoring at TAPR. MWR provided $32,000/year.

2003

Began fire effects monitoring at EFMO. MWR increased funding to $40,000/year.

2004

- Fire effects monitoring at TAPR and EFMO. MWR funding $45,000/year.
- Original fire ecology proposal: GS11 fire ecologist, GS 7 lead monitor, GS 6 assistant lead monitor, and 36 pay periods for seasonal monitors rejected.

2005

Burning began at EFMO. Report completed. MWR provided $46,000. Established new monitoring sites.

2006

- Acquired grant funding ($250,000) through the NPS Fuels Program to hire a fire ecologist: task agreement #J-6064-06-0011, cooperative agreement: CA6000030300.
- MWR provides $52,000.
- Expanded monitoring at TAPR

2007

- Hired fire ecologist. MWR provided $53,000.
- HEHO contributed $12,000 for completion of the long-term report on 21 years of data.
- Vegetation community report for TAPR completed.

2008

Acquired a funding modification (001) to add a lead monitor and a project oriented graduate student

2009

- Fire effects on Manley Woods report completed.
- Full scale fire monitoring deployed for spring fire season.

- Jackie Ebert (graduate student) worked on fire occurrence project from August 2008 to May 2009.
- MSU student worked on fire ecology bulletins.
- MSU student worked on fire effects on wildlife paper.
- Hired Lead Monitor at 74% FTE in February 2009. Upgraded Fire Ecologist to GS9.5.

2009

Acquired funding modification (002) allowed Lead Monitor to go full time @GS7 and upgraded Fire Ecologist to GS11 as of January 2010.

2010

- Five year contract with additional 18 months of funding granted.
- Fire Effects on Wildlife report completed.
- Protocol developed.

Appendix 3 - Five Year Activity Plan for HTLN Fire Ecology Monitoring

(Based on current FMPs and sampling protocol rotations)

FY 11 (October-March)

- Prescribed fire level 2 monitoring

Pre/post fire plot load: HOME (4)

- Hire/train seasonal staff.
- Complete field season preparations.
- Planning efforts: Meet with parks to review plans for the year (January).

HOME FMP revision and monitoring plan development
WICR FMP revision and monitoring plan development.
GWCA FMP revision and monitoring plan development.

- Reporting: EFMO long-term monitoring on fire effects.

HEHO five year integrated report.
Report current fuel loads to parks and FMOs.
Complete annual report for NPS fire ecology.

FY 11 (April-September)

- Prescribed fire level 2 monitoring
    - Pre/post fire plot load: HOME (4), EFMO (7), PIPE (6), TAPR (24) —Total 41.
    - Fuels monitoring at TAPR.
    - Complete data entry and quality control.
- Assist with long-term data collection at: TAPR, EFMO.
- Complete vegetation structure monitoring rotation at TAPR.
- Attend annual Patch burn grazing working group meeting.
- Reporting: Complete annual reporting and work plan for HTLN.

FY12 (October-March)

- Prescribed fire level 2 monitoring
    - Pre/post fire plot load: HOME (5), HEHO (5)—Total 10.
- Hire/train seasonal staff.
- Planning efforts: Meet with parks to review plans for the year (January).
- Five year review of HTLN fire ecology program.
- Reporting: Evaluate three years of fire ecology data.
  Report current fuel loads to parks and FMOs.
  Complete annual report for NPS fire ecology.

FY12 (April- September)

- Prescribed fire level 2 monitoring:
    - Pre/post fire plot load: EFMO (6), PIPE (7), TAPR (27), WICR (12) —Total 52.

    - Fuels monitoring at TAPR.
    - Complete data entry and quality control.
- Assist with long-term data (Level 4) collection at: WICR (prairies and woodlands), EFMO.
- Attend annual Patch burn grazing working group meeting.
- Reporting: Complete annual reporting and work plan for HTLN.
  Prepare HTLN biennial meeting update.

FY13 (October-March)
- Prescribed fire level 2 monitoring:
    - Fire effects plot load: HEHO (5).
- Hire/train seasonal staff.
- Planning efforts: Meet with parks to review plans for the year (January).
- Reporting: Report current fuel loads to parks and FMOs.
  Complete annual report for NPS fire ecology.

FY13 (April- September)
- Prescribed fire level 2 monitoring
    - Pre/post fire plot load: HOME (5), EFMO (7), PIPE (6), TAPR (36) —Total 54.
    - Fuels monitoring at TAPR.
    - Complete data entry and quality control.
- Assist with long-term data (Level 4) collection at: HOME, PIPE, EFMO, and HEHO.
- Attend annual Patch burn grazing working group meeting.
- Reporting: Complete annual reporting and work plan for HTLN.

FY14 (October-March)
- Hire/train seasonal staff
- Planning efforts: PIPE FMP revision and monitoring plan development.
  HEHO FMP revision and monitoring plan development.
  HOME assist with NRCA, revise monitoring plan.
- Reporting: Report current fuel loads to parks and FMOs.
  Complete annual report for NPS fire ecology.

FY14 (April- September)
- Prescribed fire level 2 monitoring
    - Pre/post fire plot load: HOME (4), EFMO (6), PIPE (7), TAPR (24), WICR (12) —Total 53.
    - Fuels monitoring at TAPR.
    - Complete data entry and quality control.
- Assist with long-term data (Level 4) collection at: TAPR, EFMO.
- Attend annual Patch burn grazing working group meeting.
- Reporting: Complete annual reporting and work plan for HTLN.
  Prepare HTLN biennial meeting update.

FY15 (October-March)

- Hire/train seasonal staff.
- Propose research project through CSU on fire effects on an endangered snail at EFMO.
- Submit new funding request.
- Reporting: Report current fuel loads to parks and FMOs.
  Complete annual report for NPS fire ecology.

FY15 (April- September)

- Prescribed fire level 2 monitoring
  - Pre/post fire plot load: HOME (5), EFMO (6), HEHO (5), PIPE (4), TAPR (27) —Total 47.
  - Fuels monitoring at TAPR.
  - Complete data entry and quality control.
- Assist with long-term data (Level 4) collection at: TAPR, EFMO.
- Reporting: Complete annual reporting and work plan for HTLN.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 920/106496, Month 2011

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